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BUILDING AND FLYING MODEL AIRCRAFT

A Guide for Youthful Beginners in Aeronautics

PREPARED FOR
PLAYGROUND AND RECREATION ASSOCIATION OF AMERICA

By

PAUL EDWARD GARBER

U. S. NATIONAL MUSEUM, SMITHSONIAN INSTITUTION;
MODEL EDITOR, "U. S. AIR SERVICES" MAGAZINE

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PREFACE

The purpose of this book is to present a modern work on the interesting and instructive activity of building and flying model aircraft. The development of this activity has been very rapid since the World War and the demand for data has rapidly exhausted the supply. This book is an amplification of and extensive addition to the series of Bulletins prepared by the author for the Playground and Recreation Association of America during the summer of 1927 in connection with his duties as Model Aircraft Consultant for the Association which organized the National Playground Miniature Aircraft Tournament. The Bulletins temporarily filled the demand; it is hoped that this book will more completely and permanently do so.

This book is intended for the model aircraft enthusiast, for recreation leaders, for the aid of model clubs, as a guide to manual training instructors who are including the building of model aircraft as part of their program, as a textbook for the student of elementary aeronautics, and for the committees in charge of model aircraft tournaments.

The effort has been made to conduct the reader through progressive steps in construction and theory, in each instance showing not only a new design but also a new method of construction, so that when the book has been followed to its close the reader will be able to construct any model in the most appropriate manner. Ingenuity and self-teaching have been encouraged. In preparing the drawings and photographs the aim has been to make the illustrations fully amplify the text. In general, highly technical terms have been purposely avoided

but the list at the back of the volume will explain terms that may not be fully understood.

The author has many friends throughout the country who have from time to time sent him illustrations of their models, all of which are beautifully made. It is regretted that lack of space prevents including all of them. It is thought, however, that the reader may gain a good impression of the types and construction of models from the examples given.

In accordance with the usual policy of the Playground and Recreation Association of America, plans, suggestions, pictures, and data have been sought and received from many sources, to the end that this manual would represent the results of the combined experience of many persons and thus present to its readers the best practice in model construction and operation. Grateful acknowledgment is made to all who have helped; especially to the Smithsonian Institution and the U. S. Air Corps for data and photographs; to the "U. S. Air Services Magazine" and "Science Service" for permission to revise and republish material originally written for them by the author; to the members of the National Playground Miniature Aircraft Tournament Committee, whose interest and support have helped to make the building and flying of model aircraft a nation wide educational and recreational project.

EDITORIAL PREFACE

The purpose of this book primarily is to encourage the youth of this country to become air-minded by engaging in elementary aeronautics as a sport—that is, building and flying model aircraft. The author has described in detail the methods of constructing a number of typical models having different general characteristics; also how model tournaments are conducted, with rules adopted by the Playground and Recreation Association for their competitions.

It should be understood that this book is not intended as a history either of model aeronautics or the achievements of the pioneers in aviation experimentation. The author, Mr. Paul E. Garber, is an employe of the United States National Museum which is administered by the Smithsonian Institution. Naturally he makes frequent references to persons with whom he has more or less connection. These references are not to be taken as implying that the persons mentioned were the inventors of the devices with which their names are associated.

It is regretted that the author did not include the name of Alphonse Penaud, sometimes referred to as the father of model aircraft, several of whose inventions are used in most model aircraft today. Penaud was the first to employ twisted rubber strands for driving the propeller; he also was the first to devise the successful system of inherent stability generally embodied in present-day model aircraft as well as the successful full-size airplanes.

C. deF. Chandler,
Editor

CONTENTS

BUILDING AND FLYING MODEL AIRCRAFT

NATIONAL PLAYGROUND MINIATURE AIRCRAFT TOURNAMENT COMMITTEE

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WILLIAM P. MacCRACKEN, Jr.
Assistant Secretary for Aeronautics, Department of Commerce

COLONEL THEODORE ROOSEVELT

EDWARD P. WARNER
Assistant Secretary for Aeronautics, Navy Department

FOREWORD

The building of model airplanes has long served as a practical school of aeronautical engineering and design. Some of the most distinguished of pioneers in airplane development, especially Professor S. P. Langley, used models extensively before attempting to build man-carrying machines, and the miniature airplane has continued ever since to be the subject of careful study for science and for sport.

Thousands of boys have found the flying of models a delightful pastime, but it should be more than that. The development of the model and the improvement of its record has naturally paralleled progress made with man-carrying airplanes, for the knowledge gained in one can be applied to the other. The principles of flight are always the same. The studies made in the great aeronautical laboratories are serving the end of the school boy with his model as well as of the manufacturer of airplanes for the government or for commerce. The development of models proceeds by scientific method, and the model builder has the fascinating problem of finding out and correcting, one by one, all the flaws in his product.

He cannot proceed without guidance, and if he had to depend directly on the study of full-sized airplanes and on embodying in models what he could see in their design, his progress would be slow. The model airplane and the man-carrying one are the same in principle, but they differ in many details of form, the model being fitted to its own particular purposes of test or competition. There is a science of aeronautics which is all-inclusive, but model design and building is an art in itself. Mr. Garber has written for all who are interested in that art, either as novices or experts. His book should encourage more

boys, stirred by the present world-wide enthusiasm for aviation, to take up model flying. In doing that he will be adding to the number of those who, quite without conscious effort or tedious study, come to have an understanding of the principles of aeronautical science and of the method of operation of all the airplanes which play so large a part in the present-day world.

Edward P. Warner

Assistant Secretary for
Aeronautics, Navy Department

Extract of Address on Model Aviation by F. Trubee Davison

These child-made planes are more than toys—and the flying of them is more than play. The planes and their flights together represent a definite part of the intelligent and painstaking directing of the aviation enthusiasm that has swept the country. Moreover, we all appreciate the influence exercised by children upon the adult mind and an air-minded childhood today means an air-minded public tomorrow.

For that reason, the cellars or garrets or sheds where children make their planes are as important in their way as the huge plants where real airplanes are assembled, and the parks or vacant lots or pastures where children fly their planes are as important in their way as the million-dollar airports which are the pride of some of the great cities in our country.

Children who make planes and fly them not only invest their time in an intelligent manner but they obtain definite elementary knowledge of the possibilities and limitations of flying.

F Trubee Davison

Assistant Secretary for
Aeronautics, War Department

Message from William P. MacCracken, Jr., Member of the Tournament Committee

Every American boy today is vitally interested in aviation. There is no better way for him to give expression to this interest than to apply himself to building model airplanes. Time thus spent adds to his knowledge as well as provides an excellent means of recreation. In years to come the experience thus gained is certain to be beneficial to him regardless of the occupation or profession he may select. This suggestion will probably have more influence in persuading parents to take a sympathetic interest in the subject than in attracting the boys and girls. Their interest is primarily in the sport of the thing and they are sure to find a great abundance of it.

William P. MacCracken Jr

Assistant Secretary for Aeronautics,
Department of Commerce

MESSAGE FROM ORVILLE WRIGHT, CHAIRMAN OF THE NATIONAL PLAYGROUND MINIATURE AIRCRAFT TOURNAMENT

To the Boys and Girls of the Playgrounds of America:

My first interest in aviation started with a toy flying machine when I was a boy. Since that time many marvelous things have happened in the field of aviation. The conquest of the air is a romantic story; many thrilling chapters are still to be written. The boys and girls of today are to have an important part in the aviation development of tomorrow.

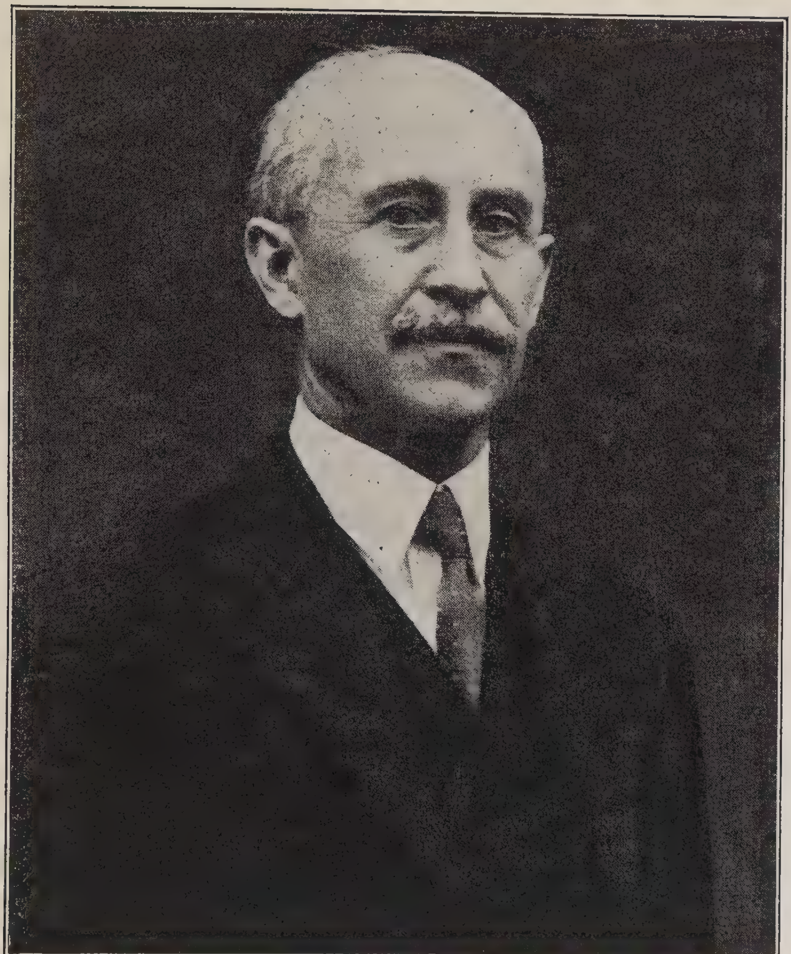
Building and flying model aircraft is not only a fascinating sport, but will be the means of helping you to understand and appreciate what is to become an important feature of our lives.

I wish all of you great success and happiness in taking part in the Model Aircraft Tournament in your city.

Sincerely yours

Orville Wright

[The above message endorsing the model aircraft tournaments of the Playground and Recreation Association should not be construed as approval by Mr. Wright for all statements made by the author of this book. —*Editor.*]



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ORVILLE WRIGHT

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COLONEL CHARLES A. LINDBERGH, Associate Chairman, National Playground Miniature Aircraft Tournament

Nov. 23, 1927

The Playground and Recreation Association is greatly assisting in the advancement of aeronautics by enlisting thousands of boys in American cities in the National Playground Miniature Aircraft Contest

As flying activities increase a basic education in elementary aviation is becoming a necessity for everyone;

Any organization thru which such education is distributed is worthy of the fullest support.

Charles A. Lindbergh

[The above message endorsing the model aircraft tournaments of the Playground and Recreation Association should not be construed as approval by Colonel Lindbergh for all statements made by the author of this book.—*Editor.*]

CHAPTER I

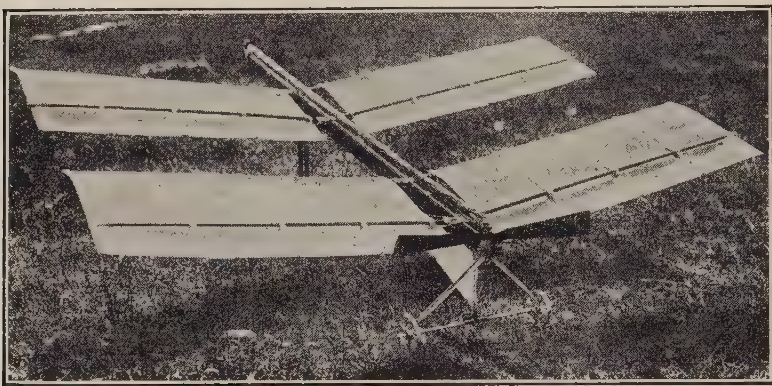
THE SPORT OF BUILDING AND FLYING MODEL AIRCRAFT

Soon after the first man-carrying flights by the Wright Brothers in 1903, boys invented the sport of model aeronautics. Youths sought to emulate their flying heroes and seized upon model airplanes as the way in which they could imitate the flying feats which filled the world with wonder. It was but natural that the first models made were miniature reproductions of contemporary machines such as those of Langley, Wright, Curtiss and Bleriot. Soon, however, it was realized that models that embodied every detail of the full-sized machines could not fly very far, because their air resistance was increased by struts, wires and fittings which, while essential to the performance of the man-carrying airplanes, hampered the flight of the models. Thus, in his endeavor at simplification, the modelmaker evolved the scientific model which consisted of the bare essentials for flight, namely, wings, propeller, and a simple frame. It is with this type of model that the wonderful records of today have been made, and the sport firmly established.

Model aircraft enthusiasts who have been in the sport since its birth enjoy many a laugh when they think of the crude models that were made in the early days. Models were made of heavy material, crudely put together and weighing several pounds, whereas now the lightest materials are used, delicate workmanship employed, and the finest long-distance models weigh about two ounces. Naturally, the early heavy

models made short and erratic flights, 50 feet constituting a good performance, and durations of 10 seconds being extraordinary.

But it was not long before the situation improved. Boys began to study more about flight and the reasons for aerial



(Courtesy: "The Aero")

Figure 1. An Early Model of the Langley Type Built by Paulhan and Houry

success; lighter and stronger materials were chosen, ingenuity was exerted to adapt various light fittings to new rôles in models, and with the combined spurs of interest in a fascinating sport and competition with fellow flyers, models flew farther and longer.

By 1909 the sport had attained considerable interest, other countries having adopted it, particularly England and France with Germany soon following. An international comparison of records resulted in Percy Pierce of Philadelphia being accredited this country's leader for a flight of over 200 feet, and the world record going to C. Fleming-Williams of England for a flight of about 1,000 feet. Pierce's record was beaten by Page in this country in 1910; he produced a model having very long and narrow wings, quite a contrast to the leaf-shaped wings of that time.

Page's record was shattered the following year when on September 16, 1911, Cecil Peoli of New York City made his model fly 1,691 feet, 6 inches, remaining in the air 48-4/5 seconds. The Peoli model became very popular and to this day

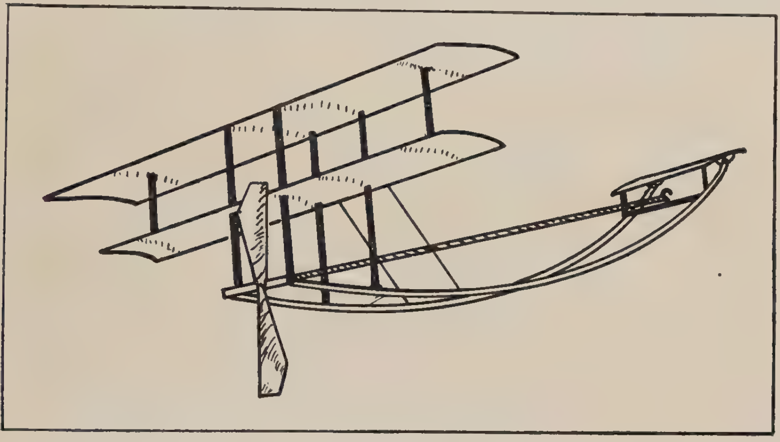


Figure 2. An Early Model Resembling the Wright Machine

remains a favorite. Models of this pattern have flown nearly half a mile.

John McMahon, also of New York, brought out a model in 1912 which was generally ridiculed by those who saw it, for they did not see how a model having such huge parts could fly. The secret was that McMahon had used balsa wood for his framework. This wood is much lighter than spruce, pine or similar woods that were used previously, but, being less strong, it required larger dimensions. When John launched

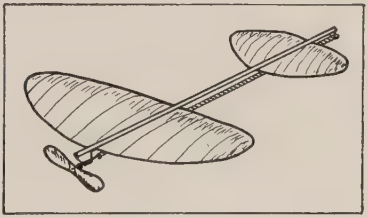


Figure 3. Pierce Model of 1909

his model, it flew the excellent distance of 2,003 feet. The world's record for that year, however, was credited to R. F. Mann of England whose model flew nearly half a mile. It was

a small, swift monoplane having a frame 34 inches in length and 7 inches in width, a piano wire framed wing and a solid wood veneer elevator. The propellers were bent from 1/20-inch birch veneer, 8 inches in diameter. The model weighed only 4 ounces and flew at about 20 miles per hour.

(Courtesy: "The Aero")

Figure 4. C. Fleming-Williams Launching His Record-Making Plane, 1909

In 1913 Armour Selley of Brooklyn, New York, attracted deserved recognition with a light and well designed model that made a trip of 2,800 feet. Its propellers were 2 inches in thickness by 1 inch in width; consequently they turned slowly, allowing a great duration to be derived from the rubber strands. This same model, when equipped with floats and launched from the water, established a world's record of 53 seconds, more than double the English record of that time.

The next model to attract attention was that of Wallace Lauder of the Aero Science Club, New York City. His model in 1916 flew 195 seconds, (more than 3 minutes) and later made a record breaking distance of 3,537 feet. By this time so many types of models had been evolved that separate records were listed for the various kinds. Two general types were in use, namely, pushers, with the propellers in rear, and tractors having their propellers in front. Under these two heads were

listed the records for models hand-launched for distance and duration, models equipped with a land chassis and rising from the ground under their own power, both for distance and dura-

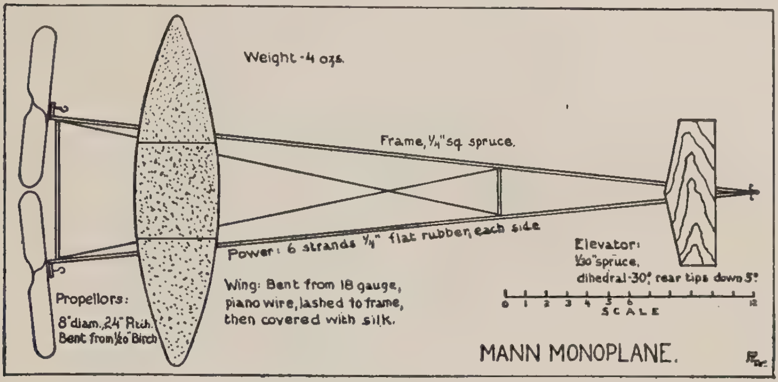


Figure 5

tion; also models with floats with which they rose from the water and flew for duration, distance being difficult to measure on the water.

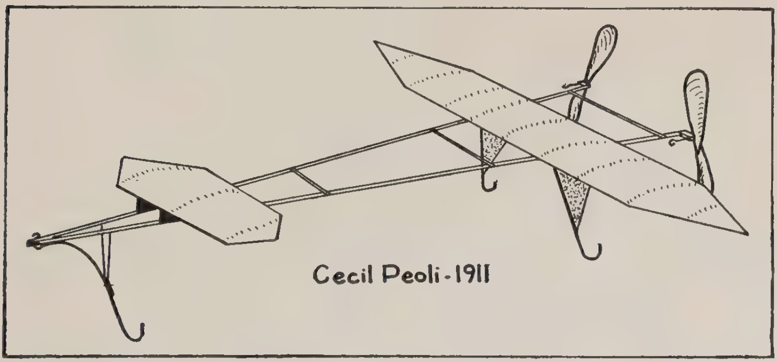


Figure 6

The World War which we entered in 1917 interrupted model aeronautics for several years, as many of the older model flyers changed from the sport of flying models to the grim necessity of their country's defence—the majority, of course,

joining the air services. The annals of the war are filled with brave deeds of former model flyers who were able to serve their country to better advantage because of their valu-

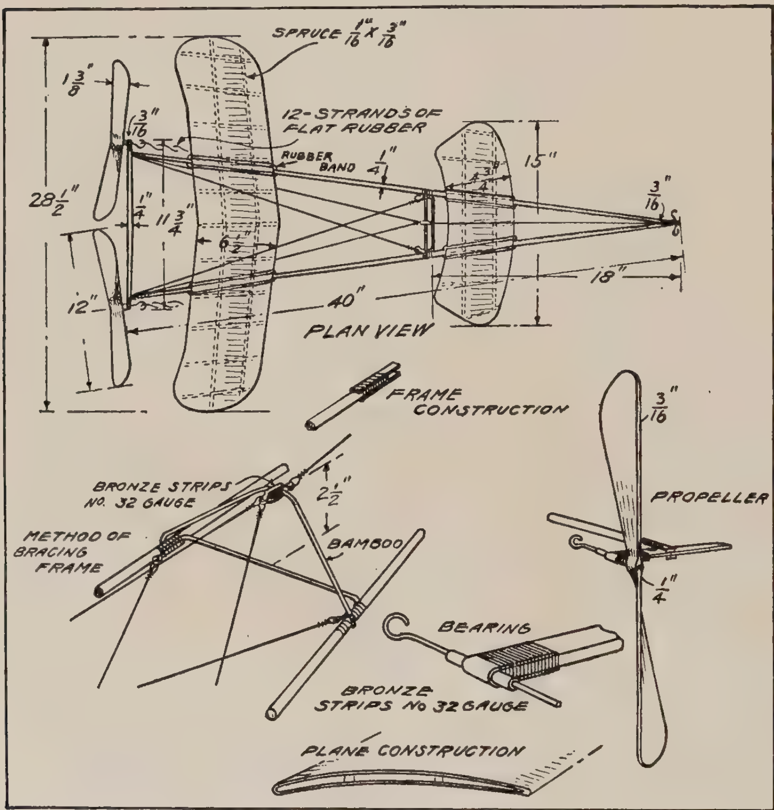


Figure 7. The Lauder Model of 1916

able training in the essentials of flying received through model airplanes.

After the war the sport was resumed, and as the science of flying had been so noticeably advanced by the exigencies of war, model flying benefited by the increased knowledge of aircraft and the records mounted. By 1922 a hand-launched twin

pusher flown by Hall of the Illinois Model Aero Club had passed the mile goal with a flight of 5,337 feet. The duration for the same type had been advanced by William Schweitzer of the same club to more than 230 seconds. A hand-launched tractor made by Lathrop, also of the Illinois club, had arrived

(Courtesy: I. M. A. C.)

Figure 8. The World Champion, Robert V. Jaros and His 10½ Minute Model

just at the 4-minute mark. In 1924 the world was astounded by Robert V. Jaros, then a student in a western college, who flew a twin-pusher model a distance of 7,920 feet and a duration of 10 minutes, 14.2 seconds. This record has not since been beaten, to date. Through the kind assistance of Joseph J. Lucas of Chicago, there is printed herewith a list of the present model airplane records as of March, 1928. It will be noticed that the Illinois Model Aero Club is most prominent in establishing these records, a fact for which Mr. Lucas, as

WORLD RECORDS FOR MODEL AIRPLANES—OUTDOOR MODELS

Model	Kind of Flight	Duration	Distance	Name	Club	Year
Twin-propeller pusher	Hand-launched	10 min. 14.2 sec.	7,920 ft.	Robert V. Jaros	Illinois M.A.C.	1924
Twin-propeller pusher	Hand-launched speed	45 m.p.h.	300 ft.	W. Wakin	Illinois M.A.C.	1920
Twin-propeller pusher	Rise off ground	3 min. 29.4 sec.		Robert V. Jaros	Illinois M.A.C.	1921
Twin-propeller pusher	Rise off ground		4,029 ft.	Wm. Schweitzer	Illinois M.A.C.	1919
Twin-propeller pusher	Rise off water	2 min. 52 sec.		Bertram Pond	Illinois M.A.C.	1921
Single-propeller pusher	Hand-launched	2 min. 48.5 sec.		Walter L. Brock	Illinois M.A.C.	1924
Single-propeller tractor	Hand-launched	9 min. 42.2 sec.	6,024 ft.	Paul Schiffler-Smith	Illinois M.A.C.	1924
Single-propeller tractor	Rise off ground	3 min. 47.4 sec.	2,685 ft.	Phillip Breckenridge	Illinois M.A.C.	1917
Single-propeller tractor	Rise off water	1 min. 56 sec.		Lindsey Hittle	Illinois M.A.C.	1915
Twin-propeller pusher	Junior class, hand-launched	5 min. 37 sec.		Jack Lefker	Illinois M.A.C.	1927

a director of that club, is partly responsible. The club is to be congratulated upon such an excellent showing.

The reason that foreign models do not appear in these records is that European model practice leans more to the use of miniature reproductions of the full-sized machines, which of course are heavier than scientific models. Lately, however, the English particularly have evinced an interest in the lighter construction and we may therefore expect some keen competition in the near future.

Lately a movement has gained much favor among model flyers; it is conducting indoor contests using models smaller and lighter than those used outdoors, and adjusting them to maneuver within a large building. Such contests are most entertaining to spectators as it is not necessary to follow the model over a large field, and the intricate and skillful movements of the models are a delight to the eye. Indoor contests have brought about a resurrection of scale models in this country. Because small reproductions of the full-sized machines are heavy and frail, they are awkward to operate outdoors where wind currents and rough ground make flying difficult and landings hazardous. Indoors, however, they can operate in still air and land on a smooth floor. Two types of full-sized miniature reproductions are specified, namely *scale models* and *fuselage models*. The first term, synonymous with commercial models, means an exact miniature flying reproduction of the prototype, with the same wing setting, control placement, etc. Of course, in the large machine the weight of engine, fuel, pilot, etc., determines the wing placement, and when reproduced in miniature, the wing placement being the same, weights must be added in the proper places to compensate for the difference. This, of course, handicaps the model. Where the model is a reproduction of its original but whose wing can be moved for proper placing in relation to the model's different

INDOOR RECORDS, DURATION ONLY

Model	Kind of Flight	Duration	Name	Club	Year
Scale	Rise off floor	22.4 sec.	Robert V. Jaros	Illinois M.A.C.	1921
Fuselage	Rise off floor	1 min. 36 sec.	Donald Lockwood	Illinois M.A.C.	1928
Twin-propeller pusher	Hand-launched	1 min. 35 sec.	Carl Carlson	Illinois M.A.C.	1928
Single-propeller pusher	Hand-launched	1 min. 49 sec.	Donald Lockwood	Illinois M.A.C.	1928
Single-propeller tractor	Hand-launched	2 min. 53 sec.	Wm. Chaffee	Michigan M.A.C.	1926
Glider	Hand-launched Junior	8 sec.	Burton Simcox	Knoxville, Tenn.	1927
Glider	Hand-launched Senior	10.2 sec.	C. Krejci	Chicago, Ill.	1927

There is at present no international agreement on glider records, due to difference in launching heights in this country and abroad. The Playground and Recreation Association of America has established 6 feet as its standard, and on that basis the attainments of the 1927 tournament are here given.

center of gravity, the result is called a fuselage model. These not being handicapped by weights can fly much farther and longer. The world records for indoor models are also given.

(Courtesy: N. A. A.)

Figure 9. The Mulvihill Trophy Representing Icarus Testing His Wings

Advances in model flying have been greatly stimulated by the awarding of prizes to successful entrants, and the holding of contests. Prominent aeronautical magazines have frequently donated handsome trophies for model competitions. In 1923, B. H. Mulvihill, then vice-president of the National Aeronautic Association, donated a handsome trophy for supremacy in duration flights. It is contested for yearly and is

one of the greatest incentives for the sport. William B. Stout, himself a former model flyer and now famous for his Ford-Stout all-metal aircraft, has donated another fine trophy.

The Playground and Recreation Association of America, shortly after the return of Colonel Charles A. Lindbergh from his famous flight from New York to Paris, realizing that this achievement had aroused interest in all forms of aeronautics to a fever heat, desired to assist the youth of America in the building and flying of models. Information on the subject was scarce, and so a committee of prominent airmen was formed to assist the boys. Orville Wright and Colonel Lindbergh were chairmen and they were ably assisted by many of the most prominent airmen of the country. The author had the honor of serving the committee as technical advisor. This committee prepared and disseminated information to hundreds of cities throughout the country where local contests were held and the winners finally assembled for the deciding competition at Memphis, Tennessee, October 8, 1927. The results of this nation-wide contest were deeply gratifying to the organizers, and it has been the means of stimulating and assisting the sport greatly.

Thus we have learned how model flying developed. It is an excellent means of *manual training* and many schools have adopted model airplane making as a feature of their program. The youthful modelmaker, in the desire to improve his models, is unconsciously led to undertake *helpful study.* Because the flying of models requires clear weather and open fields, with need for running to regain a model after a successful flight, model aeronautics constitutes a *healthful exercise.* In the association with fellow enthusiasts and competitions, the devotee learns the lessons of *competition* and fair play which are so helpful in later life. Model flying is indeed an enjoyable and worth-while sport.

CHAPTER II

ELEMENTARY AIRCRAFT

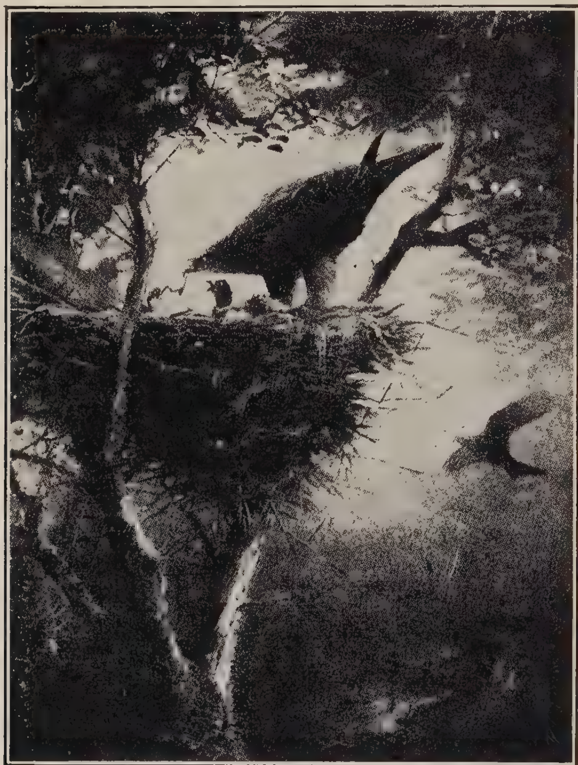
Every boy finds delight in sports of the air just as he does in land sports like baseball and tennis or water sports like swimming and rowing. The aerial sport de luxe is, of course, making and flying model airplanes, but the lesser ones such as kite-flying, boomerang throwing, flying tops, etc., are instructive and enjoyable.

Kites are believed to have been invented by the Chinese thousands of years ago. In the years since then many interesting kinds have been developed and today the Chinese fly kites of weird and wondrous shapes as a feature of their holidays. Kites are so called after the bird of that name (see Figure 10) which has long been noted for its high soaring flights.

The simplest kite is the square shape formed by two sticks of equal length crossed at right angles in the center, surrounded by an outline of string and covered with light paper. Benjamin Franklin used such a kite in his famous lightning experiment, but his was covered with a silk handkerchief, as it was flown during rain. Such a kite, or others of single flat surface, require a tail which steadies the flight, but of course adds weight which holds the kite down somewhat.

A more efficient kite made with two sticks is the Malay kite illustrated in Figure 11. The main dimensions are given in the drawing. The sticks are straight-grained light wood such as pine or spruce, 5/16 inch square. The string outline is tied to the sticks in notches at the ends. The reason that

the Malay kite does not need a tail is that steadiness is imparted by curving its surface. It is interesting to note that the steadying principle of the curved-surface Malay kite is



(Photo of Painting by Charles Whymper)

Figure 10. The Kite (Milvus ægyptius)

essential for the lifting surfaces of airplane wings. Tie a string to one end of the cross-stick and fasten it to the opposite end after bowing the stick so the string is 6 inches from the cross joint.

The frame is covered with tissue paper, first spreading the paper out on the floor (pasting two or more sheets together

to make the required area if necessary), then laying the kite belly-down on it and cutting the outline, leaving a margin of ½ inch all around for pasting. Roll the kite over to meet

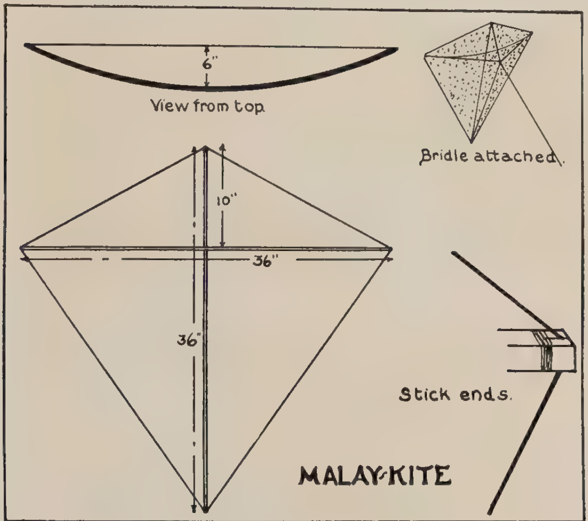


Figure 11

one side, coat the margin with paste, fold over the string and fasten down. Do the same with the other side. Attach the bridle which consists of crossed strings tied to the points of the kite with their crossing about a foot away from the kite surface. To the junction, the kite string is attached.

Figure 12 shows a three-stick kite which may be made flat and flown with a tail, or if curved like the Malay kite, no tail is necessary. A kite tail is made by knotting pieces of paper or cloth about 6 inches square, in a string, a foot apart. The length of the tail will depend upon the amount of balance required and the wind velocity; it is determined by experiment, starting with, say, 20 feet for a 3-foot kite.

Nearly any flat surface or combination of surfaces can be made to fly as a kite, by using the correct bridle, and having

the surfaces in proper relation and balance, using a tail if necessary. Because of this fact many novel kites have been

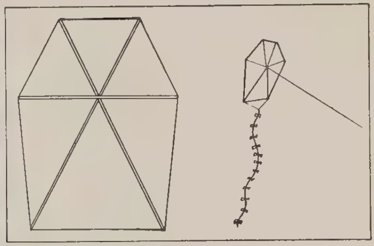


Figure 12. Three-Stick Kite

made. Figure 13 shows a "Felix" kite patterned after the cartoon cat. Its frame and one for a butterfly kite are shown

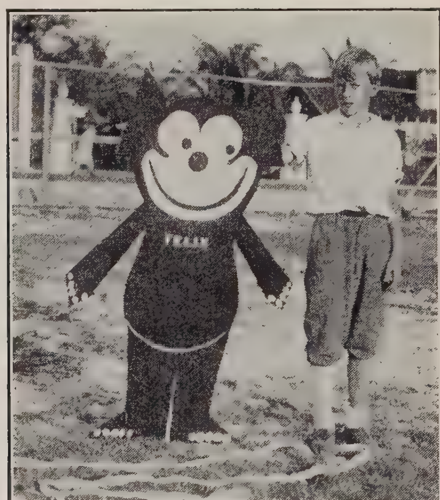


Figure 13. "Felix" Kite Made by Erich Jordahn, West Palm Beach, Fla.

in Figure 14. Curved shapes in frames can be made by bowing thin sticks of pine, or if the shapes are ornate or of small radius, thin sticks of split bamboo or pieces of wire are

preferable. Bamboo can be bent by holding it above a candle flame and working it to shape as the heat loosens its fibers. Bridles for figure kites are made similar to those on the Malay

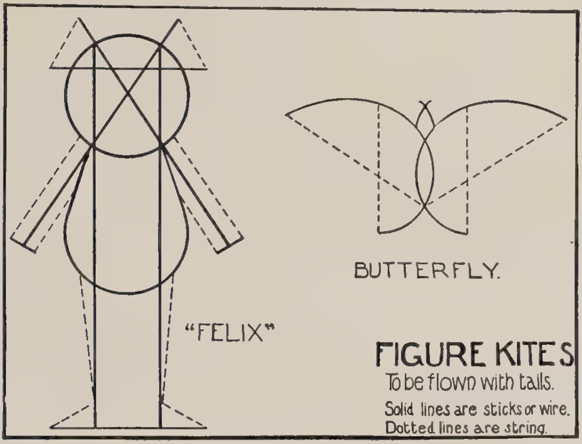


Figure 14

and three-stick kites, and are attached at the extremities. Using colored paper or decorating the finished kite makes a pleasing effect.

A Box Kite

The box kite was invented about 1895 by Lawrence Hargrave of Australia, during his experiments in aeronautics. In the desire to secure forms which were stable when in the air, he devised cell-like structures of various shapes; some were cylindrical, some square, some rectangular, etc. Many of his devices were flown as kites, others were supplied with power. One of the latter is shown in Chapter XXIV. The box kite is often called the Hargrave kite, after its designer.

To make a good box kite (see Figure 15) obtain the following lengths of well-seasoned, strong, light, straight wood, 5/16 of an inch square.

4 pieces 36 inches in length
8 pieces 24 inches in length
8 pieces 12 inches in length
4 pieces 27 inches in length

Using two each of the 36- and 24-inch pieces, form two rectangles, making the joints with small nails and a strong

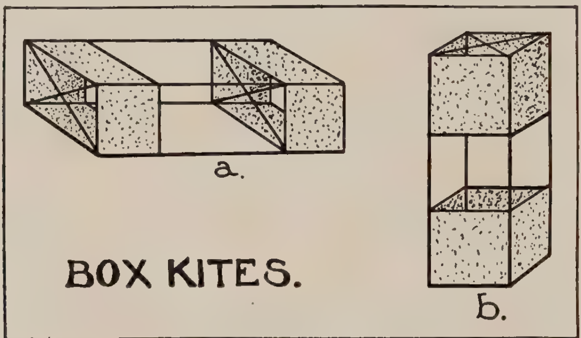


Figure 15

adhesive. In each rectangle, the shorter pieces should be between the long pieces. Next, 9 inches from each end fasten a 24-inch piece. Join these two frames with the 12-inch pieces attached where the 24-inch pieces intercept the long ones. Brace this frame by means of the 27-inch pieces, putting them diagonally in the cells at each end, so that, looking from the end, they appear as an "X." They are fastened by cutting V-slots in the ends to fit the long strips, gluing and nailing them in place. The joints should be slightly offset from the right-angled ones, to keep from weakening the wood with too many nail holes in one place.

The cells at each end are now covered with paper or cloth. If the latter is used, it should be China silk, cambric, or other light material. It is attached by gluing, stretching it smoothly, and after it is dry, painting with a thin solution of starch to fill the mesh and make it more airtight. The bridle is a string

50 inches in length attached on each side at the bottom of the upper cell. The kite string is fastened to it at the center.

A box kite which is square-shaped at the ends (Figure 15-*b*) can be made from four 36-inch pieces and sixteen 12-

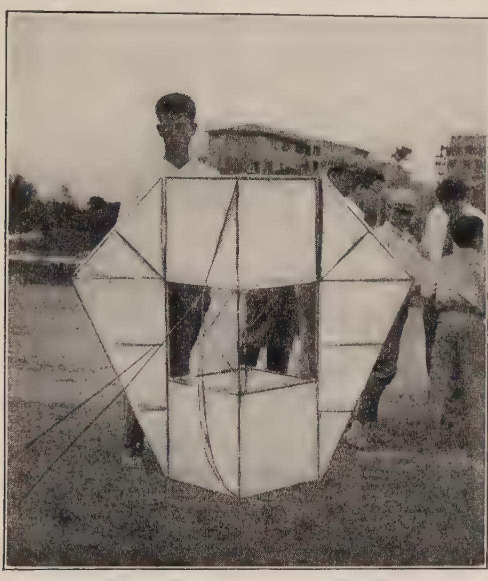


Figure 16. Kite Made by George Miller, West Palm Beach, Fla.

inch pieces with four diagonals for bracing. The cells at each end are a foot square and a foot in length. The bridle is fastened at the top and bottom of one stick, and the kite string is fastened opposite the bottom of the upper cell. Box kites require no tails; they fly steadily and at high elevations. A combination of the box and flat kites is shown in the photograph, Figure 16. It is about 4 feet in length, with other dimensions in proportion.

Any pleasant breezy day will do for kite flying. Light but strong string must be used; the lighter the string, the less load the kite has to carry. Huge kites are flown with wire,

such as piano wire. The string can best be handled from a reel. Figure 17 shows the simplest form made of four sticks and revolved by rotating the hands as though they were feet on a bicycle. To launch the kite, have an assistant hold the kite in the air facing the wind, with the tail, if any, coiled at his feet so it will pay out without tangling. Walk about 50 feet away from the kite, into the wind, paying out string as you go, then run with the kite that your assistant has released as he felt the string tug at it. Continue to unreel string as you run; soon you can stop and the kite will keep its elevation, gaining more as additional string is unwound. The height it attains will depend on its size, length and weight of string, and the wind velocity. Records of the Weather Bureau show that kites have been elevated nearly 5 miles.

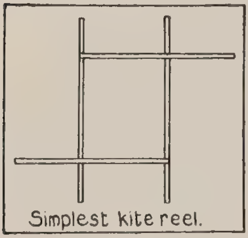


Figure 17

Kites have been of scientific value in carrying aloft instruments for recording wind velocities and temperatures at various heights. When the suspension bridge over Niagara Falls was built, the engineers got their first line across by flying a kite over the chasm, then attaching successively heavier lines to the kite string until the main cable was pulled over. Kites are used to display advertising banners; they have been used as signals in war time and even for carrying men into the air for aerial observations, as shown in the photograph, Figure 18. By combining the kite principle with a balloon, the observation balloons of modern warfare have been made more steady.

Just as scientists have found new uses for the kite, so the youthful kite enthusiast can devise means for increasing the pleasures of kite flying. One way is by sending up "messages" to the kite. These are small pieces of paper with a hole in

the center for the string to pass through. When these are placed over the kite string, the wind carries them up to the kite. By adapting the principle of the "message," a kite-line traveler can be made as follows:

Procure the following material:

1 piece of wood, 1 x ½ x 8 in.
3 10-in. pieces of wood, ¼ in. square
1 piece of light cloth, 10 in. square
2 small pulleys
4 small screw-eyes
1 piece of small wire, No. 16, 8 in. in length
String, nails, thread and needle

(Courtesy: Major Ernest Jones)
Figure 18. Man-Lifting Kites, Flown in Tandem

By referring to the drawing, Figure 19, it will be seen how the screw-eyes are placed in one end of the block of wood, and how the wire is bent to fit in them. One of the 10-inch pieces is nailed to the block perpendicularly with another piece crosswise at the bottom. The third piece is used as a boom for the cloth which is fastened to it by sewing through the cloth and over the stick. The bottom of the cloth is similarly fastened to the crosspiece. A piece of string acts as a guy for the mast. A loop of string is tied to the sail-boom and the two pulleys are screwed into the top of the block. If pulleys are unobtainable, screw-eyes make a good second choice.

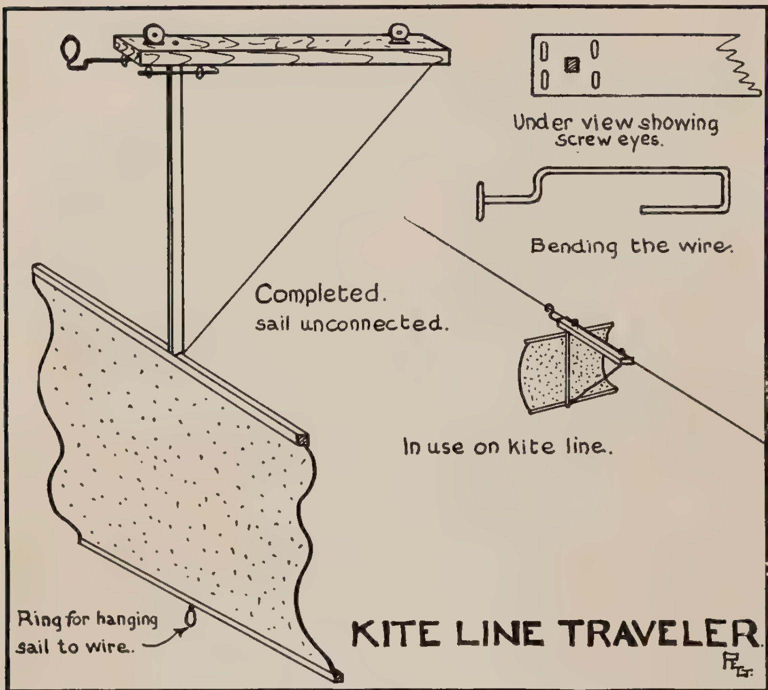


Figure 19

The traveler is now completed and ready for use. Put a wooden button or similar obstruction on the kite string up near the kite, and test its placement by making sure that the wire in front of the traveler will hit it when the traveler is run along the line. Now fly the kite in a good stiff breeze, put the traveler on the line, set sail by pulling up the boom and fastening the loop between the screw-eyes on the wire. Push it along the line a bit and the wind will take it along up to the kite where the wire will hit the button, the sail will fall,

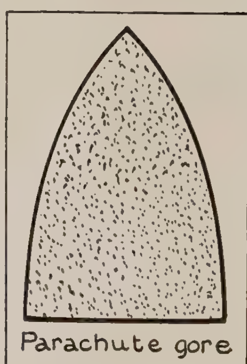


Figure 20

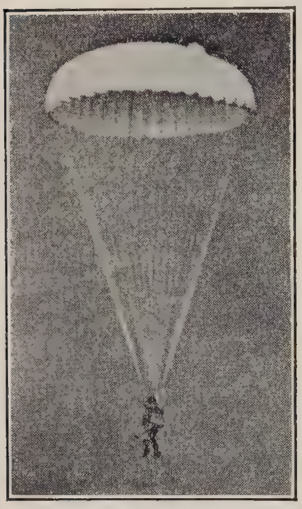
and the traveler will come back down to you to be set for another trip.

Parachute dropping from kites is another good sport. First make the parachute. A simple one may be constructed by

Figure 21. Richard and Edward Hamilton's Model Parachute

tying long strings to the corners of a handkerchief, fastening a stone to their ends, folding it up carefully, and throwing it into the air; it will unfold and come slowly down as a parachute. A better one may be made by stitching together eight

gores of the shape shown in Figure 20 and attaching strings to each seam, joining the strings at the bottom and attaching a weight. Figure 21 shows a good parachute made in this manner. It uses an old spark plug for weight. Figure 22 shows a man-carrying parachute of modern military type.



(Courtesy: U. S. Air Corps)

Figure 22. A Full-Size Parachute

It will be observed in Figure 21 that Dick Hamilton is holding the parachute by a small ring in its top. Figure 23 shows how this ring is hooked onto a traveler made of a block of wood with the screw-eye and wire release. When this is placed on the kite line, the wind catches the chute and carries it on the traveler aloft to the kite where the wire release hits a button, and the chute is released. The traveler comes back down the line like an express train; it is better to stop it with a heavy stick rather than with the hands. Another method of releasing a parachute from a kite is to attach it to the kite, before ascension, with a piece of punk which in turn is lighted and tied to the kite. The kite is then flown with the chute attached, but when the punk burns down to where the string is tied the chute is released. The slow and graceful descent of a parachute from a high flying kite is a pretty sight and adds greatly to the thrill of kite-flying.

Aerial photographs can be taken easily from a kite string by making a platform similar to the one shown in Figure 24. The shutter lever on the camera is tied to a spring which is kept from operating it by a piece of string tied to a piece of punk. To set the camera, have a friend hold the kite string of

a high-flying kite while you take the platform; then hooking your finger over the string, run down the string for as long a distance as you dare without bringing the kite too low. Attach the platform to the string by the wires, light the punk and release the kite string, when the kite will again go aloft carrying the camera with it. In due time the punk burns down, the restraining string is burned through, the shutter is released and the aerial picture taken. Adjustment of the platform is necessary to get the angle of picture desired. Such an apparatus is often used by commercial photographers, for taking views of landscapes, and before the use of airplanes it was a valuable military means of securing information.

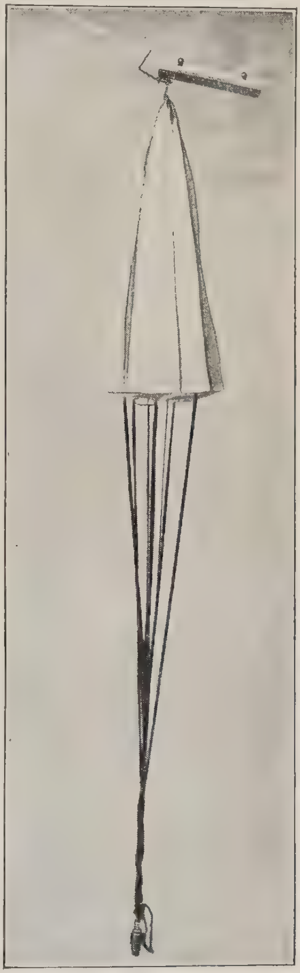


Figure 23. A Parachute on a Kite Line Traveler

Boomerangs

These curved sticks which, when properly thrown, will return to the thrower and can be made to perform other evolutions, are in reality a form of aircraft and obey definite laws of flight. They are believed to have been invented by the aborigines of Australia, although similar sticks are found among certain tribes of American Indians. The full-page illustration (Figure 25) shows an Australian aborigine holding a boomerang, with other forms of throwing

sticks grouped around the picture. Specimens 1, 4 and 5 are original Australian boomerangs, 1 being an exceptional specimen 27 inches long weighing 13 ounces and collected over a

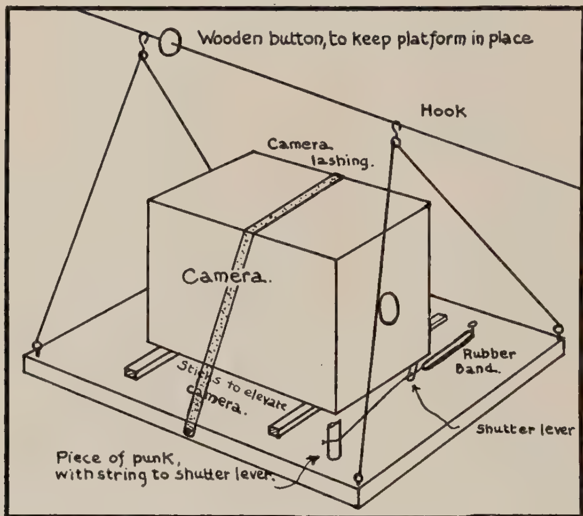
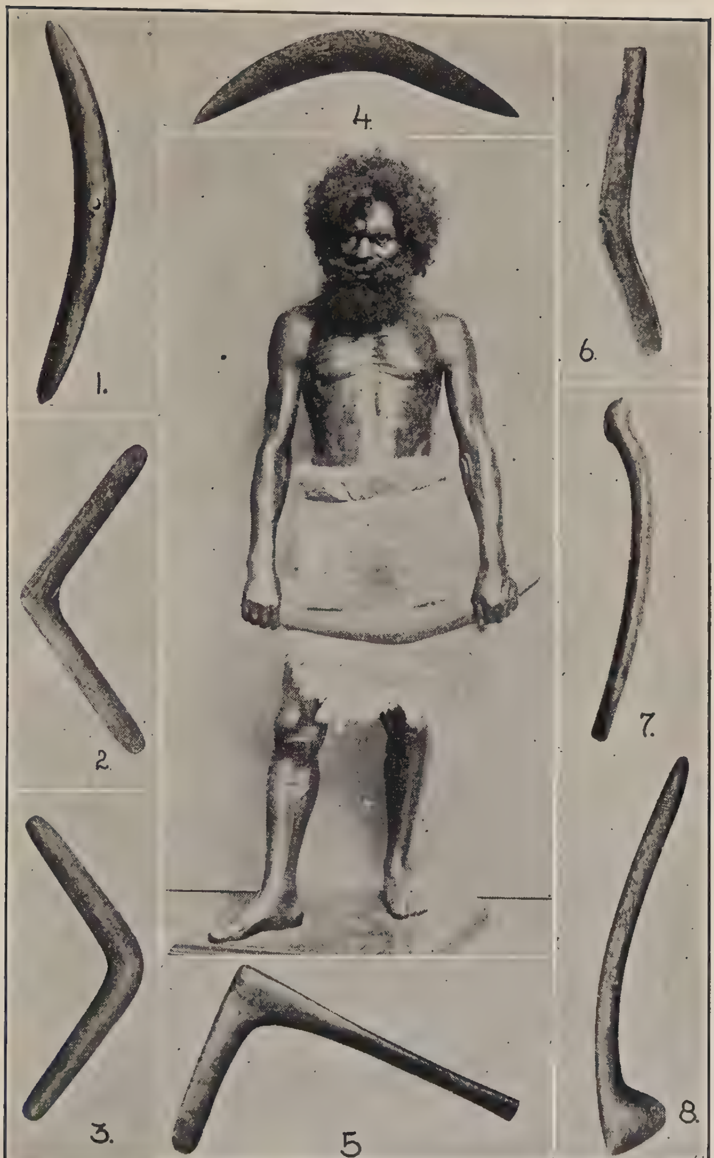


Figure 24. Camera Platform

hundred years ago. Specimens 2 and 3 are commercial articles made in this country for devotees of the sport. Sticks 6, 7 and 8 are rabbit-sticks and will be mentioned further on.

The reader can make a boomerang by copying the illustrations given in Figure 25 which are all photographed to the same scale. The section of a boomerang is flat on the bottom and slightly curved on top, as shown by Figure 26. Rather heavy wood should be used as the important spinning action must be maintained by the weight of the stick. The native boomerangs are made from a tree limb which naturally has the desired bend, but the same shape can be obtained by joining two pieces at an angle, using a halved-together joint or a butt joint strengthened with a central piece of fiber or metal, held in place by adhesive and small nails. After sawing out the



(Courtesy: U. S. N. M.)

Figure 25. Australian Native with Boomerang.
Various Types of Boomerangs

shape, the wings are easily made to the correct section with a drawknife and spokeshave. Sometimes the wings are slightly twisted from the center.

Boomerang throwing requires some practice to perfect. The method of throwing is similar to that used when skipping

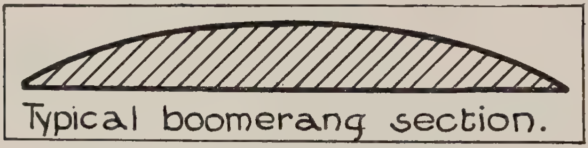


Figure 26

stones but not necessarily in a horizontal plane because the boomerang will naturally take a correct flying angle. As the boomerang leaves the hand, the fingers should jerk back upon the wing in order to give it a spinning motion. Varying flights can be obtained by changing the speed of rotation in relation to the speed of forward motion, and by throwing at different angles.

Because the boomerang was originally used as a weapon and missile for killing birds and small animals, it is well to use care in throwing it. The thin edges make it difficult to see and it has a habit of appearing suddenly from some direction, totally different from that in which it was thrown.

Three rabbit-sticks are shown in the illustration, for comparison with the boomerangs. They have a double convex section and are thrown overhand, traveling in a vertical plane with a spinning motion. Upon striking the ground they bound and rebound in a circular area, making it difficult for any animal in that space to avoid being struck. The two upper illustrations are of American Indian types; the bottom one is Australian. They are made from a piece of naturally curved wood which has a knot or knob at one end.

Flying Tops

These little devices are in reality helicopters or vertically ascending aircraft. They are easily made and serve not only for amusement but also as an introduction to propeller carving. Figure 27 shows how one type is made.

Secure a block of white pine or similar wood, 6 x 1 x ½ inches. Bore a ¼-inch hole in its center, then whittle each

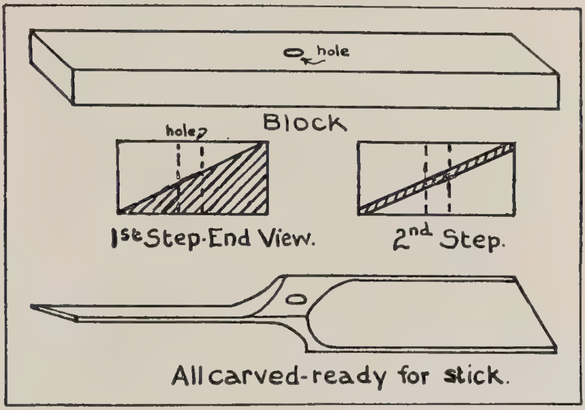


Figure 27. Wooden Flying Top

end from the upper left-hand edge to the lower right-hand edge, carving nearly to the hub. Do the same on the other blade, then turn over and repeat, leaving the blades 1/16 inch in thickness. Put a needle or nail in the center hole and balance the blades; if they do not balance, cut away on the heavy side until it evens up. Sandpaper smooth. Get a ¼-inch dowel stick and cut off a 7-inch length. Push this in the hole, using a little glue. This completes the top. Figure 28 shows how it is launched, holding it in the palm of the left hand with the fingers of the right. Then by pushing forward the right hand and opening the hands, the top is spun and mounts high into the air.

Another flying top is illustrated in Figure 29. It requires as material a tin can, spool, pencil, piece of string and two small nails. Cut the can open and cut out a flat propeller to the shape shown. Punch two holes through, ¼ inch from

Figure 28. Launching the Flying Tops

the center. Now center the hub of the propeller over a spool and mark where the holes are, then drive the nails in these marks, cutting them off ⅛ inch high. Bend the right edge of each blade upward a trifle. Put the spool on the pencil and see that it revolves freely. Wrap the string around the spool so that when the string is pulled the spool will rotate like the hands of a clock. Notice in Figure 28 how the propeller is laid on the spool with its hub-holes over the nails. When

the string is pulled, the propeller will rotate, leaving the spool and spinning up into the air.

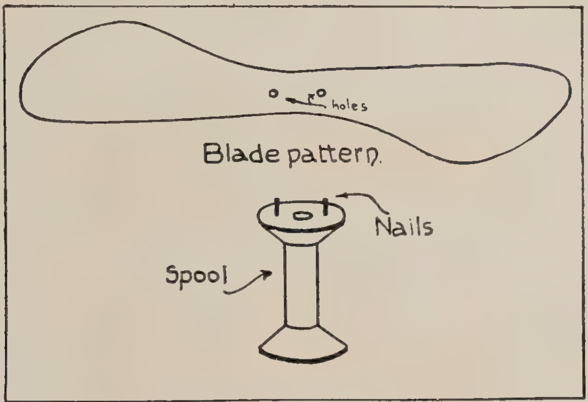


Figure 29. A Metal Flying Top

If higher flights are desired, cut down the hub of the spool so the string can impart more revolutions to the blade. Increasing the blade angle will result in quicker climb but less duration.

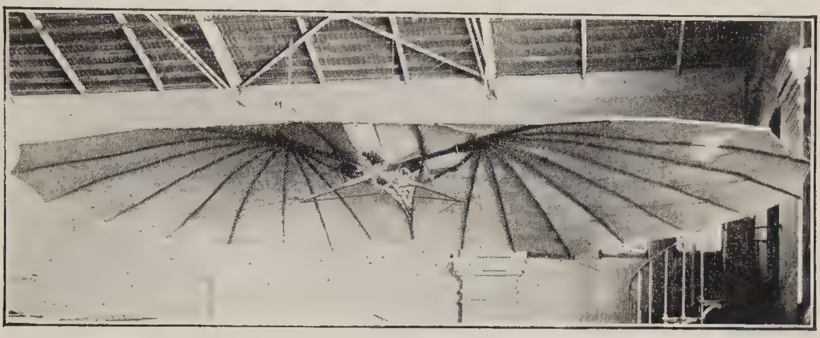
CHAPTER III

GLIDERS

A glider is a heavier-than-air craft which has no contained power plant, but derives its lift from the reaction of wind on the wings as it coasts through the air. Because a glider weighs more than the surrounding air it is always falling through the air, but it may encounter a rising current that will lift it upward; or in still air it may coast at a descending angle, moving forward many feet while descending one foot. Early in the history of flying, man discovered the gliding principle probably by watching birds soaring and alighting, also falling leaves. The throwing of flat stones and shells was probably the first experiment which led to the making of gliders. Sir George Cayley of England (1773-1857) made a man-carrying glider about 1820; prior to the twentieth century the greatest success in gliding was obtained by Otto Lilienthal of Germany who made over 2,000 successful glides with bat-like planes. (See Figure 30.)

The Wright brothers, the first men to fly, learned how to control their machine by experimenting with gliders. In 1911 Orville Wright remained in the air in a glider for 9 minutes 45 seconds. This constituted an international record until after the World War, when the Germans, restricted in their aircraft power plants by the peace treaty, turned to gliders as a means of increasing their knowledge of aerodynamical shapes. Such efficient machines were evolved that skillful operators could remain in the air nearly all day, that is, as long as the sun produced ascending currents. These remark-

able records are made by locating an upward air current, being elevated by it and at the same time gliding downward relative to the air, but turning frequently so as to stay within the rising



(Courtesy: U. S. N. M.)

Figure 30. Otto Lillienthal's Glider, 1895

column of air. Thus man is imitating nature; for soaring birds such as the turkey-buzzard, eagle and albatross have traveled hundreds of miles at a time without beating a wing,

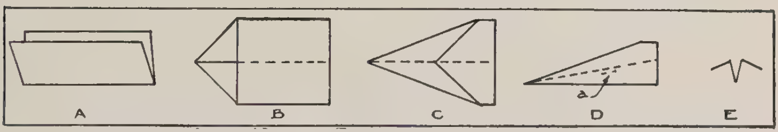


Figure 31. Folded Paper Glider

merely by their marvelously developed instinctive ability to detect proper air conditions for gliding.

Model gliders which boys can make are of various kinds, the simplest being folded paper, familiar to most boys but illustrated in Figure 31 for the benefit of those who are not familiar with them. At *A* the paper is folded in half. *B* shows the two front corners folded in to the center line which was formed when the paper was first folded. *C* shows how the remaining corners are folded again to the center line.

D shows the glider folded on the center line and the dotted line indicates how the sides are folded back. *E* is an end view of the completed glider. A pin may be put in at *D-a* to hold it together. It is grasped between finger and thumb at that

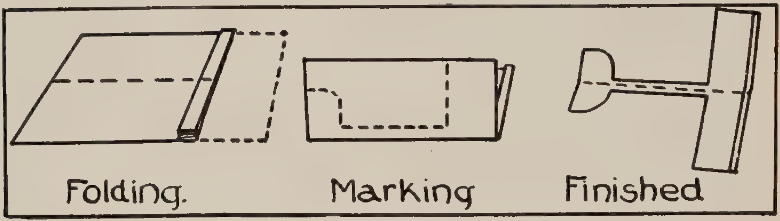


Figure 32. Airplane Shape Paper Glider

point and thrown forward. A little turning up of the back corners will sometimes improve the glides.

A more conventional glider is made as shown in Figure 32, folding over one end of a piece of paper about 8 inches square in small folds for about 3 inches. This is now folded on the center line and cut or torn out in an L shape so that when opened up it will resemble an airplane. It is held by the tail with the thumb on the bottom and finger on top and launched at a small downward angle with a slight push. It will make graceful dives and curves and by bending its tail and wing rear edges, the performances can be varied.

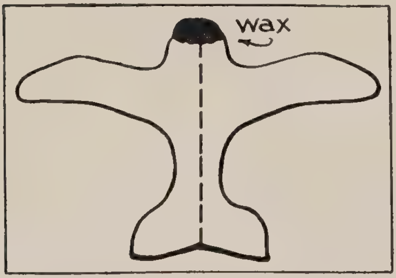


Figure 33. Bird-Like Glider

A similar glider (Figure 33) which eliminates the bulky front wing edge, is made by cutting out a bird-like shape and slightly weighting its front with a paper clip, a few drops of candle grease or sealing wax. It is similarly held and launched.

Gliders assume a nose-downward position when in the air in order to apply the force of gravity to produce falling with the front wing forward. This downward inclined position is obtained either by weighting the nose as in the two gliders

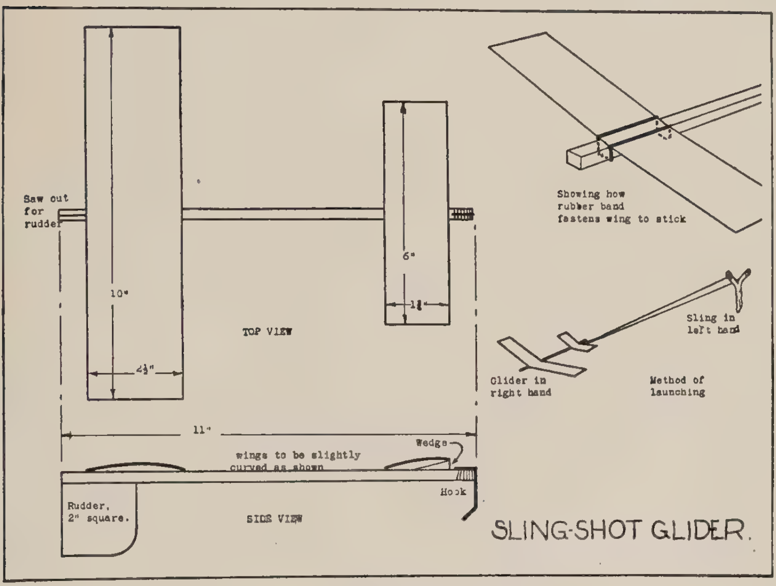


Figure 34

just described, or providing less lifting surface in front as in Figure 31. A glider of the latter type is readily made out of easily found materials, by reference to Figure 34.

Procure a piece of stiff, thin cardboard or wood veneer 10 x 5 inches, a piece of wood ¼ inch square and one foot in length, two small rubber bands and a piece of small stiff wire about 2 inches in length. Cut from the cardboard or veneer two rectangles, one, 10 x 2½ inches and the other 6 x 1¾ inches. These are the wings. Cut another piece 2 inches square for the rudder, rounding off one corner as shown in the side view of the drawing (Figure 34). The same view shows also a

wedge placed under the leading edge of the front (small) wing. This wedge is made by cutting off one inch of the stick and cutting it in half diagonally. The wire is bent into the shape shown and lashed to the front of the stick. In the other end a 2-inch saw cut is made and into it the rudder is glued. The wings are slightly curved as shown in the side view and placed on the stick approximately in the positions shown in the top view. They are secured with rubber bands as shown in the detailed drawing. This completes the glider itself.

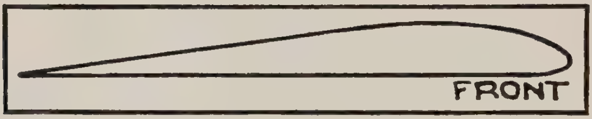


Figure 35. Wing Section

The glider may be launched by throwing with the hand alone, or by use of a sling. To make the latter, take a small tree crotch and bind to its upper ends a strip of rubber about one foot in length, cut from an inner tube, or linked up from rubber bands. To launch the glider, hold it by the rudder in the right hand, with the sling in the left. By stretching the rubber and releasing the glider it can be launched to make long glides, and by adjusting the positions of the wings and raising or lowering the edge of the elevator with the wedge, various aerial evolutions can be produced.

An improved glider for hand or sling launching may be made by using thicker wood for the wings, so shaped to have a wing section as in Figure 35. If balsa wood is available it is best because of its lightness: the size may be also increased a little in proportion. The sling action may be increased by using a longer elastic tied to two stakes driven into the ground about 2 feet apart, or held in the hands of an assistant. With such an elastic the glider can be drawn back 5 or 6 feet before

releasing. These gliders travel fast and can be made to barrel-roll, loop, etc.

Figure 36 shows an efficient glider of the weighted-nose type. It is rather heavy in order that it will have kinetic energy, or momentum. The fuselage is carved from a piece of pine 3 x 2 x 28 inches. The wing is shaped with a cross-section

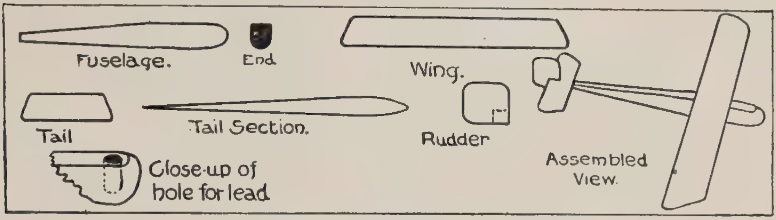


Figure 36. Hand-Launched Glider

similar to Figure 35, from a piece of pine 30 x 4 x ⅜ inches. The tail is made from a piece 12 x 3½ x ¼ inches, but it does not have a lifting section, being shaped like the detail drawing. The rudder, 4 x 4 x ¼ inches, has the same section. To assemble, the rudder is glued and nailed in a slot in the fuselage as in the sling-shot glider. The tail is nailed on the fuselage at the back, and the wing is fastened with a strong rubber band as was the wing on the sling-shot glider. The front edge of the wing is elevated by a piece of wood about ⅛ inch square and 2 inches long. Tie about an ounce of lead to the nose for a weight.

To launch, choose an eminence or the side of a hill, face the wind, grasp the fuselage at the balancing point, and thrust the model from you with a spear-throwing motion in line with the shoulder. Aim it a trifle below horizontal. If it rises and stalls, falling back on its tail, increase the weight, or move the wing back, or lessen the wing angle by cutting down the elevating stick. If it noses down too abruptly, lessen the weight, move the wing forward or increase the wing elevation.

Make any or all of the above corrections until the glider performs satisfactorily. When the proper combination is arrived at, glue and nail the wing in place, with a sloping wedge of proper elevation; for the weight, bore a hole in the nose of the fuselage, melt the lead and pour it in.

Astonishingly long glides can be made with this type of model. Sometimes it may encounter a rising air current and be carried aloft whence it may make a long return glide; or if upset by a gust, it may nose over and dive until its speed forces a greater lift on the wing and raises the glider into normal position. Under such circumstances it may travel fast and entirely out of the expected path, consequently it is best to watch it intently and be ready to move if the glider should suddenly dive earthward. This type can be improved by making the fuselage from balsa wood and forming the wings and other surfaces in a manner similar to that specified for some of the flying models that will be described subsequently; that is, by building them up from spars and ribs, and covering with fabric. A skid-landing chassis can also be added to absorb the shock of landing.

All of the previously described gliders depend for their duration in the air upon their forward speed and consequent lift. Since the advent of championship contests with model gliders, a type has appeared, made extremely light, which depends for duration upon its slow wafting descent to the ground. The construction of these is similar to that of the indoor tractor model described in Chapter XVI, with the difference that the power plant (propeller, rubber, bearing, etc.) is eliminated and a slight weight added to the front. Needless to say, such gliders are made as light as possible and, since no power is used, the fuselage stick can be cut down.

Thus we come to the end of elementary aircraft, and if the reader has constructed the various types described thus

far, he has made all the essential parts of a model airplane—the wing, propeller and frame. It remains only to assemble these, improving them by alterations which increase their flying power, and a tangible beginning is made in model aviation.

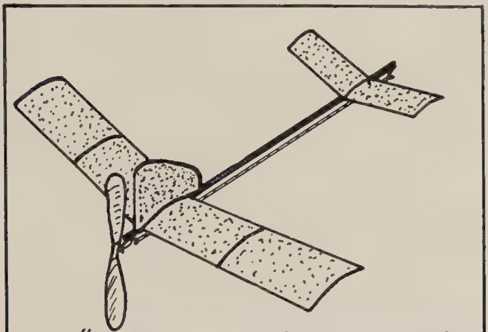

The "Single Pusher" completed.

Figure 37

Figure 37 shows a model which is essentially a combination of the glider shown in Figure 34 and the flying top shown in Chapter II. Of course, the combination of these two exact elements would make a rather heavy model, so a lightened form of construction is advocated and described below.

Procure the following material:

1 piece wood for fuselage stick, 16 x 1/4 in. square
2 pieces wood for wing edges, 22 x 1/8 x 1/16 in.
1 block of wood, 7 x 3/4 x 5/8 in.
32 inches of small wire, preferably aluminum No. 16
1 sheet tissue paper
1 small nail, No. 16, 1 in. in length
2 small washers or 1 bead
4-in. small stiff wire

The construction steps are shown in Figure 38. First make up the stiff wire (which may be procured from a hat-

pin, bicycle spoke, paper clip, hairpin, etc.) into the shaft *A* and the nose-hook *B*. The nail is pounded on the head and drilled as shown at *C*, then bent for 5/16 inch at one end. If this proves difficult, a similar fitting can be bent from wire as shown at *D*. From the aluminum wire, cut three pieces 2¾ inches in length and five pieces 3¼ inches in length, bending ⅛ inch of each end at right angles and flattening it, then forming the main length into a parabolic curve as shown at *E*. The remaining piece of aluminum wire is bent to the rudder outline *F*.

The four flat sticks are bent slightly in the middle as at *G* by holding their centers above a candle flame and forming the bend as the heat loosens the wood fibers. The ribs are now bound onto these sticks to make the frames *H* and *I*, the wing and elevator respectively. All of the wire ribs should face as at *E*, the right being front. Use Ambroid over the bindings to increase the strength. These two frames are now covered with tissue paper by coating one panel at a time with adhesive, then applying the paper, stretching it smooth and pulling taut lengthwise to preserve the curvature.

The next four sketches show the propeller, which is made similar to the flying top. Lay out the block with diagonals on its face *K*, marking their intersection at the exact center and drilling there a hole for the shaft. Cut out the block to these lines, resulting in *L*. Now carve it as you did the flying top, namely, from the upper left-hand edge of each blade to the lower right-hand edge; turn it over and cut the backs leaving a thin blade *M*, and finally putting a needle through the hub and balancing the propeller thereon; if one blade is heavy, whittle until it balances. Put the shaft into the hub and secure it by bending over and binding the projecting end, as at *N*.

Assemble the model by binding the hook and nail to oppo-

site ends of the stick. Secure the wing and elevator with rubber bands as was done with the sling-shot glider. Put the ends of the rudder frame in holes fore-and-aft of the wing, then cover the frame. Put a ⅛-inch elevating block under

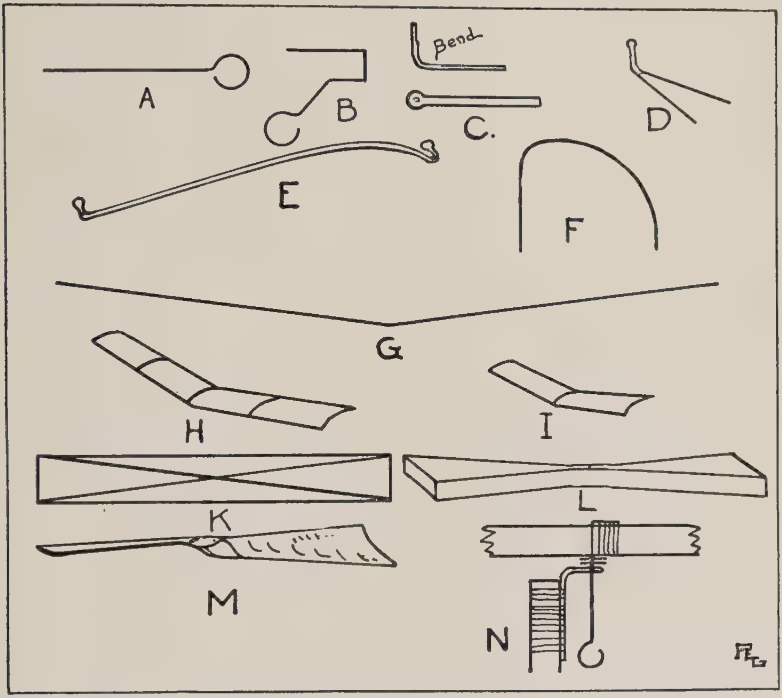


Figure 38. Single-Pusher Construction

the elevator's front edge. Put the propeller in the nail as at *N*. Tie the rubber thread into a loop and coil it six times between the shaft hook and the nose-hook. This completes the model which is shown in Figure 37.

Select an open space for flights. Wind the propeller about a hundred times in the direction of rotation opposite to that which is necessary to blow air away from the model. Face the wind, hold the stick in the right hand and restrain the

propeller with the left. Release the propeller and a moment later cast the model gently forward at a slight upward angle. If it climbs too rapidly, move the elevator back; if it dives, move the elevator forward. When properly adjusted good flights will result.

CHAPTER IV

TOOLS AND MATERIAL FOR MODEL AIRCRAFT CONSTRUCTION

Model aircraft making does not require an expensive outlay for tools and material. Some of the finest models have been made with only a few common household tools and an old table for a work bench, although it is of course true that better equipment insures greater convenience in doing a piece of work. A good list of tools would consist of the following:

Penknife
Razor blade
Ruler
Pair of round-nosed pliers
Pair of flat-nosed pliers with side cutters
Pair of scissors
Small plane
Drill
Hammer

Good examples of each are shown in Figure 39. The penknife should be sharp; the type of blade shown is adapted for making short slits and for carving the curvature in the propellers. The razor blade is used for some delicate trimming. The ruler should be about 3 feet in length for convenience. The round-nosed pliers are used for bending hooks and other special forms of wire, while the flat-nosed pliers are used for gripping and straightening. The cutters on the latter are used for cutting the wire. Scissors are used for cutting wing covering, etc. The plane shown is the handy little

"Stanley 75" but any small one will do; it is used for dressing the wooden strips. The drill shown is of the type known as a "pin vise." It can be rotated between thumb and fingers. It holds in its chuck a No. 61 drill which is the size generally used for drilling propeller hubs, shaft bearings, etc. A geared hand drill will, of course, do a quicker job but it is more expensive. The hammer is used for driving small nails, forming metal, etc. The uses of each tool will be made more familiar in describing the model parts themselves.

Other conveniences needed are a block of metal to hammer on, a candle and some various grades of sandpaper. With the above equipment the reader can embark with confidence upon the construction of most of the models herein described. For some he will find additional tools necessary; for instance, Chapter IX describes the "Humming Bird" which has wings made of wire whose joints are soldered, thus a soldering set is needed. Chapter XXI describes a small compressed-air engine, in which the metal work will require the use of a hacksaw, files and various sizes of drills. The making of models that resemble the full-sized aircraft often calls for ingenious use of materials and special tools. In this modern age there are so many helpful machines that by their use short-cuts to the finished product can often be taken. In this instance, if the modelmaker has access to a circular saw, he will be able to cut out wooden strips with greatest ease. A band saw is ideal for cutting out propeller blanks, and a machine drill insures accurate drilling. A good modelmaker will use the tool best suited to the job and will keep his tools in fine condition.

Too much emphasis can not be given to neatness, not only in the work done, but also in the method of working. Some constructors will be able to fix up a nice little shop, but others, confined to the limits of a city apartment, will probably have less space. Even they, however, can probably secure the use

of a drawer for tools, and it is suggested that they make a box, like that described in Chapter XIII, in which to keep parts and

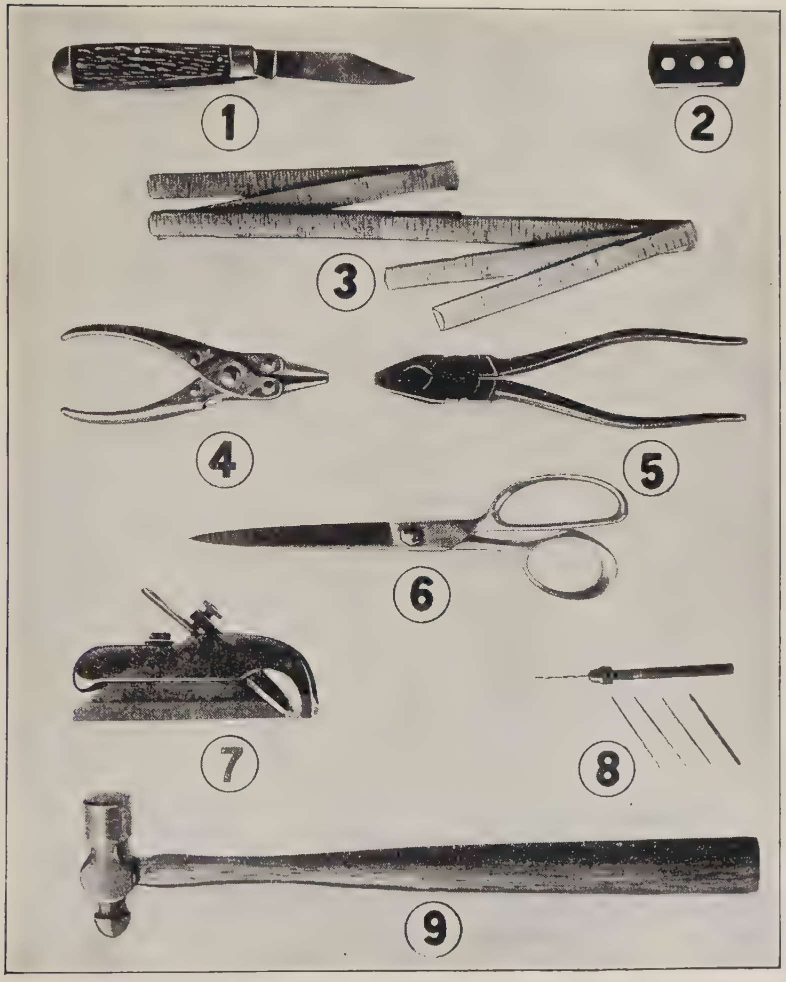


Figure 39. Tools for Model Aircraft Building

finished models. Keep your models away from harm. Inquisitive fingers and careless feet have ruined more good

models than have bad landings. Sometimes an attractive model can be suspended from a chandelier or fixture and thus serve as an ornament and be out of the way. Parents will always be glad to help their youthful modelmaker, and he

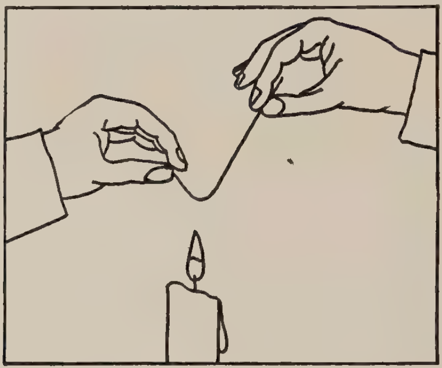


Figure 40. Bending Bamboo

must cooperate by keeping his tools, models and his workshop in order.

Materials for model aircraft construction may be grouped under four heads, namely, wood, metal, fabric and liquid. The best woods are spruce, bamboo and balsa. Spruce and sprucelike woods, such as white pine, cypress, redwood, basswood, fir and poplar, any of which can be substituted, are procurable from packing cases, building construction, or direct from the lumber yards. The wood can be sawed or split to approximate size, planed to a finish, and then used for frame construction, wings, struts, etc. Bamboo is a hollow cane with a shiny outer surface, divided into sections separated by nodes. It can be procured in the form of fishing poles from sporting goods stores, and as rug poles from furniture stores. A discarded porch screen may be of bamboo, or an old piece of furniture may have been made of this wood. It can be sawed to the proper length and split to size, and for the smaller

strips it may be smoothed most accurately with a plane. Bamboo, when heated above a candle flame, becomes pliable and may then be bent to any desired shape for use as wing ribs, wing ends, landing gear, wing outlines, etc. It is very strong.

(Courtesy: American Balsa Co.)

Figure 41. A Balsa Tree

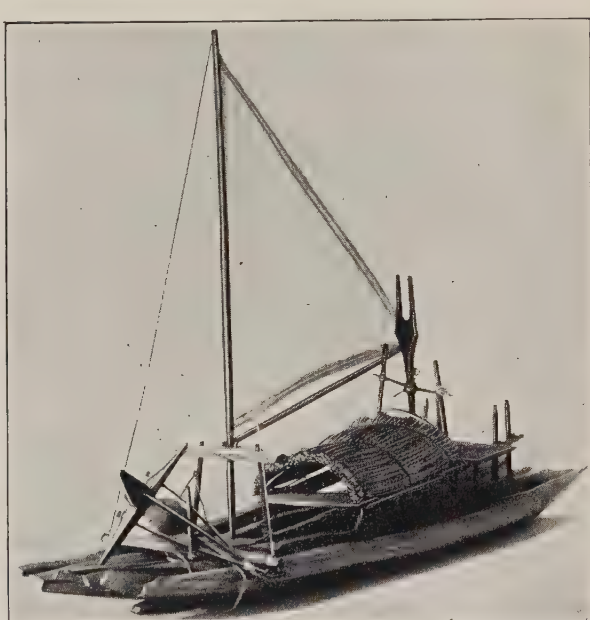
Only splits of bamboo which have the original shiny outer surface are suitable for models. If the piece of bamboo desired is longer than that contained between two nodes, the node can be carefully cut through with a knife. Figure 40

shows how bamboo is held when being bent. Slight bends may be made with other woods in a similar manner. Broom straws can be used for parts of light models.

Balsa is the lightest useful wood known. There is one species of wood lighter but it is little more than punk and

(Courtesy: American Balsa Co.)

Figure 42. Equal Weights of Balsa and Quebracho (heaviest) Wood



(Courtesy: U. S. N. M.)

Figure 43. Brazilian "Balsa" or Raft, from which the wood derives its name. These small craft sometimes sail hundreds of miles off the coast of South America.

rapidly decays. Balsa is lighter than cork and about half as strong as spruce. It is ideal for model aircraft and all modern records in this sport are due to its use. It is found in Central America where the tree grows rapidly to about 10 inches in diameter. In addition to being used for model aircraft it is used for life rafts, aircraft shaping parts where

strength is not required, and for insulation from heat or cold as in refrigerators where its multitudinous air cells protect the contents from changes in temperature. In this connection it is used by manufacturers as containers for shipping perishable goods such as yeast, and it may be procured from handlers of this product. The term "balsa" is the Central American name for rafts made from this wood. Modelmakers can get balsa from large lumber yards, from the importers of foreign woods, from aircraft factories or from an airport. It should be sawed to size and planed to a finish, using a very sharp plane worked at an angle. Similarly, when a penknife is used on balsa, the blade should be handled with a slicing stroke rather than with a direct forward cut.

Metal is used for several of the model aircraft fittings. Small headless brads are used for the propeller bearings, as explained in Chapter VI. Other fittings are made from wire which may be obtained from hairpins, hatpins, paper clips, bicycle spokes, etc., but preferably in rolls of music wire, procurable from hardware and music stores. Sizes 10 and 15 are most used. Piano wire is sold in one-quarter and one-half pound coils, costing at present fifty cents for the smaller coil, which will do for hundreds of fittings. Small washers are used to reduce friction in the bearings; they can be bought at hardware stores by specifying size 15. Dress spangles, sold by notion or trimming stores, also make good washers. Some modelmakers produce their own washers by taking an ice-pick and punching small holes in a sheet of thin metal; then punching out the metal around the center holes with a round ticket-punch. Other parts, such as metal sheet, tubing, etc., may be purchased from hardware stores, or obtained for the asking from the junk boxes of garages or shops. Small steel wire, No. 32, will be useful for binding wood and fittings together. It is sold in spools at hardware and ten-cent stores.

The use of fabric occurs mostly in the covering of wings. For permanence China silk is preferable as it is light, strong, and inexpensive. Practically all notion stores carry this and it retails at about one dollar a yard and may be obtained in all colors. For the very light scientific models, tissue paper is used. This may be the kind sold in ten-cent stores, or if a

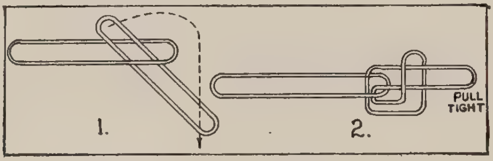


Figure 44. Linking Rubber Bands

tougher product is desired, use rice paper, sold by draftsman's supply houses, or Japanese silk tissue paper sold by Oriental novelty and art stores. Another fabric employed for covering wings is goldbeater's skin, which is a very light-weight animal membrane, being the lining of part of a cow's digestive tract. It can be purchased in sheets from model supply houses, but is comparatively expensive.

Under the subject of fabric we will consider rubber, which is used almost universally for the power in model aircraft. The best form is the rubber thread, procurable direct from prominent rubber manufacturers, costing about one cent a foot. Rubber thread is used in golf balls, and it may be obtained by taking one apart carefully. The shock absorber cord used on man-carrying aircraft is made up of lengths of rubber thread. Rubber bands may be chained together to make up the desired length for a model, as shown in Figure 44. An old automobile inner tube may be cut up into loops or strips. Rubber can best be cut when it and the knife are wet; therefore to cut an inner tube, moisten the tube and the knife with water, cutting along a straight edge, making thin, uniform strips. Rubber bands about 3 inches in length are used to

hold the wings onto some models. Smaller bands, known as election bands, are useful for holding the rubber hanks onto the motor fittings. Stationers carry these. For protecting the rubber hanks from being cut when under tension, by the metal fittings, small rubber tubes are used. These may be procured from opticians in the form of spectacle tubing, or a substitute may be found by stripping the insulation from telephone or electric light wire, and using the rubber tube therein. Silk thread is used for lashing parts together; size "A" is best.

One liquid used in modelmaking is adhesive. For this purpose ordinary glue is sometimes used, but a cellulose product known as "Ambroid" is much superior as it is waterproof, more tenacious, and dries quickly. It may be procured from sporting goods dealers and hardware stores. Another liquid used on models is known familiarly as "dope." It is a preparation applied to the wing covering to make it tight, airproof and strong. Various forms of dope are used, but the most common among modelmakers is banana oil, procurable from paint and drug stores. Often it is thickened with celluloid, which may be in the form of sheet or a remnant of some celluloid product such as a comb, toothbrush handle, etc., dissolved in the banana oil. A solution of acetone, another drug-store product, and celluloid may be used. Standard airplane dope often is procurable from any flying field, and may be used as it comes or diluted with acetone. Dope is also used as an adhesive for fastening the fabric to the wings. Collodion, also a drug-store product, can be used as a wing coating solution. All of these are highly volatile and should not be used in poorly ventilated places as their fumes are somewhat stifling. Light machine oil is, of course, a useful liquid for lubricating the model bearings. Glycerin, obtainable from drug stores, is used by some modelmakers on their rubbers to lubricate the strands, thus enabling more turns to

be stored in them. Talc, powdered mica and cornstarch act as lubricants and preservatives for rubber.

The above materials can be used for all general purposes, but occasionally pieces of toys and other mechanisms are found which will be adaptable for model construction. For example, wheels for landing chassis can be obtained from ten-cent store toy wagons. Imitation radiators for the front of scale models can be built up very realistically by gluing together small pieces of soda fountain straws. Numerous other forms such as pilot's head rests, dummy motors, spinner caps, etc., can be built up of "plastic wood"; it is a product that works like putty but dries like wood and is obtainable from hardware stores.

Again referring to bending bamboo and other woods, it has been found that some bends can be made easily by laying it against a hot electric lamp bulb, soldering-iron or other hot metal. This method is less liable to char the wood.

When giving the sources for various materials in this chapter, mention has been made of general local agencies, but the reader should know that there exist excellent firms who specialize in supplies for model aircraft makers. Their names may be found by consulting any good boy's magazine or aeronautical publication; in their catalogues will be found special articles for models and all of the material referred to in this chapter.

CHAPTER V

HOW TO MAKE MODEL AIRCRAFT PROPELLERS

Propellers are often spoken of as air screws, and that title explains their action by indicating that they screw their way through the air just as a corkscrew when turned moves through a cork. However, because air is not a solid like cork, propellers do not advance with 100 per cent efficiency, but "slip" a certain amount. This slip is reduced by careful designing and proper relation between the propeller and plane. Early propellers were very inefficient, but it is interesting to know that the propeller was designed for a flying machine long before it was thought of as a means of moving ships.

Upon the propeller hinges the success or failure of a model's performance. The design should be correct, the carving well done and the balance perfect. Propellers are carved from any of the light woods such as spruce, pine, bass, poplar and fir, although balsa is preferable for racing models. The first step is the choice of design and size; next comes the making of the blank and finally the carving. The first step is covered by the plans of the model which you have selected for construction, or if you are making an original model, reference to Chapter XIX will help you in the design of the propellers.

The blank is the piece from which the propeller is carved and its blades may be of various patterns. Figure 45 shows several blade patterns which represent modern usage. Sketch 1 shows the Langley type, made famous through its use on the successful aircraft of the pioneer Samuel Pierpont Langley. Sketch 2 is that adopted by the Wright Brothers and might

be described as a Langley type with one corner cut off. Sketch 3 shows the Columbia type which is similar to a Wright but with its corners rounded off. Sketch 4 shows the type used extensively by the United States Navy on its man-carrying planes.

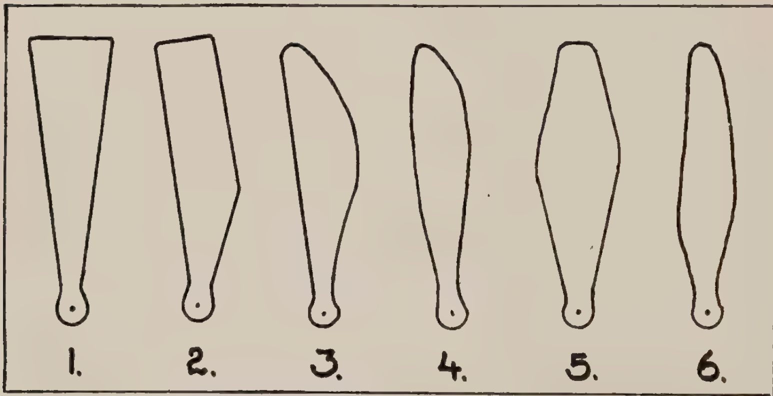


Figure 45. Types of Blades

It differs from the Columbia in having both edges rounded. Sketch 5 is the Diamond pattern which performs well. Sketch 6 is the Carter type which differs from the Diamond in that the projection of the leading edge is advanced from that of the trailing edge. It is used on many of the thin-bladed metal propellers that are so efficient on full-size planes. All of the above designs are popular, but the Langley is the easiest to lay out and carve.

To lay out the Langley "prop" (see Figure 46), select a rectangular block of wood having the length, width and thickness of the propeller needed. Lay the piece on its side and draw diagonals on its face from corner to corner. These should intersect at the center, and at that point drill a hole for the shaft. Next, saw down the diagonals almost to the center but leave a little wood there for the hub. Carve the

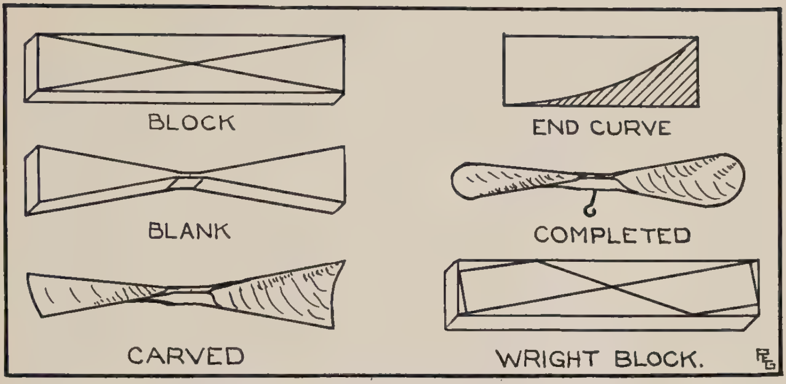


Figure 46. Langley and Wright Propellers

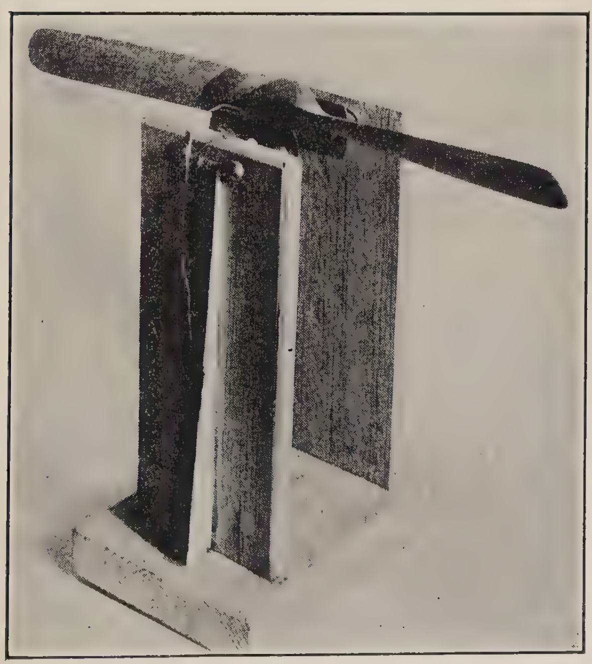


Figure 47. Propeller Balancing Frame

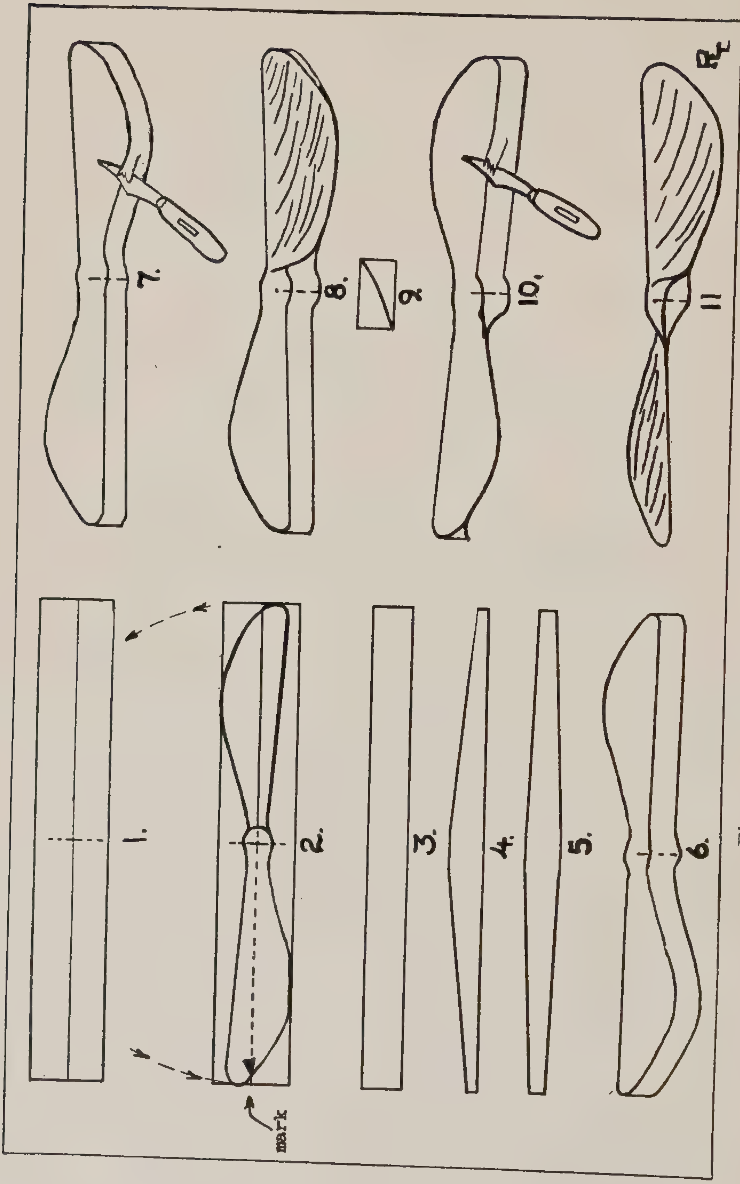


Figure 48. Laying Out and Carving a Propeller

blades, using a sharp penknife and cutting from the upper edge to the opposite lower edge of each blade, which when finished should be slightly curved as shown. Put a needle through the shaft hole and balance the blades. Because the pointed ends of the Langley propeller are inefficient, these ends should now be rounded off, after which the prop is again balanced. Figure 47 shows a home-made propeller balancing frame, having razor blades for its edges, thus insuring very little friction. The completed propeller blades should be very thin so that when held before a light they will be pinkish, but gradually thickening into the hub.

The last sketch in Figure 46 shows how a Wright blank may be laid out by drawing the second diagonal from points equidistant from each end, but this, as well as any other blade pattern, may easily be laid out by following the method illustrated in Figure 48, where the Columbia type is taken as an example. Sketch 1 shows the piece of wood from which the propeller is to be carved. It may be as large or larger than the finished blank. A line is drawn upon it, slightly longer than the propeller diameter. A pattern of the desired blade consisting of the hub and blade, which should be as long as the radius of the propeller, is then cut from cardboard and a mark made on the end. A pin is pushed through the center of the hub and then stuck into the center of the line on the block. The mark is laid over the line and the outline of the pattern is drawn on the block. Next, swing the pattern around so that the mark is over the opposite end of the line as shown in Sketch 2, and again draw the outline. This method insures the blades being alike and opposite.

The blank is now cut out. The ideal tool for this is a band saw, but if one is not available a key-hole or coping saw will do, or an ordinary straight saw can be used for the major cuts,—the final shape being made with a knife.

The next step is to drill a hole through the hub, doing this carefully and making sure it is perpendicular to the surface. In the case of a pine propeller, a bench or hand drill may be used, but with balsa propellers the wood is so soft that an ordinary pin can be pushed through it.

We are next concerned with the edge which may be left rectangular as shown in Sketch 3, or tapered either from one side or from both sides, as in 4 and 5. A rectangular edge produces a slow-turning prop, good for duration; a tapered blade turns faster and imparts speed to the model. The blank cut out is shown in 6.

Sketches 7 to 11 show how the blank is carved. It will be noticed that the curved edge is chosen for the entering edge of the prop. This is in accordance with best results, as curved entering edges have proved to be better than straight ones. In Sketch 7 the carving is started; a gouge may be used instead of a knife if care is taken not to cut too deep. The wood is cut away from the upper edge to the opposite lower edge, curving the blade slightly as shown in Sketch 9. Next, carve the same side of the opposite blade, put a needle in the hub and balance the blades evenly, then sandpaper smooth. The other sides are cut as shown in Sketch 10. As the blade nears completion, be careful not to cut through in your eagerness to make a thin blade. The progress in cutting can be watched by frequently holding the blade to the light and noticing by the pinkness of the wood how thin it is becoming. When finished it should be slightly less than 1/16 of an inch in thickness, gradually increasing to the hub; the outer two-thirds should be uniformly thin. The propeller is again balanced and sandpapered, and the hub cut down as much as possible to reduce weight, but not at the expense of strength. The propellers of record-making models have hubs as thin as ⅛ of an inch, but for the modelmaker's first efforts, he should

have a thicker hub to avoid the possibility of breakage. Some prefer to cover the tips with silk to prevent breakage, which is a good idea but it must be done neatly to keep down the skin

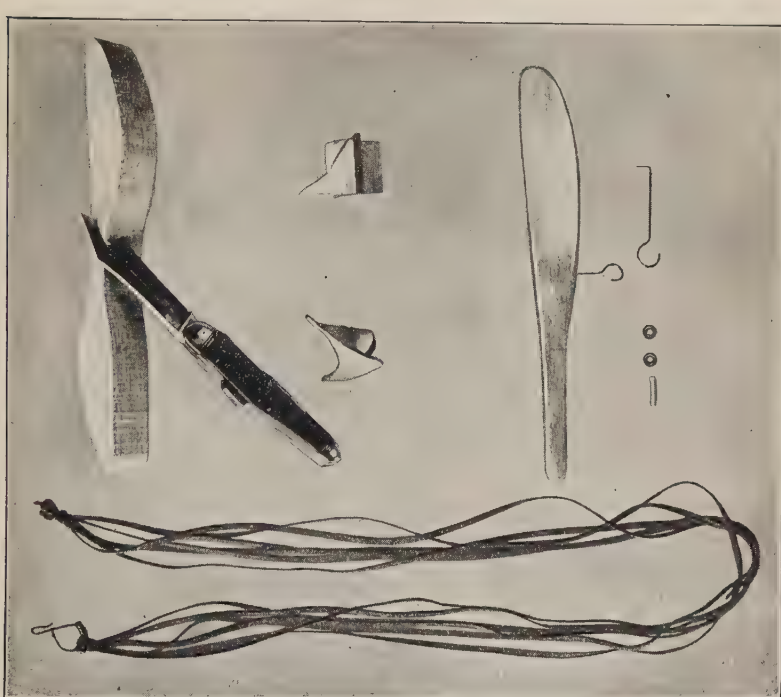


Figure 49. Propeller Carving and the Rubber Motive Power

friction. Dope is the best adhesive for this, and covering of one side is sufficient.

The foregoing description applies to a right-handed propeller; a left-handed one is carved by making the cuts in the opposite direction; that is, the blank would be laid as in Sketch 6 and the cutting done from the upper right-hand edge to the lower left-hand edge. A right-hand and a left-hand propeller are shown in Figure 50.

Figure 51 shows how the propeller is fastened to the frame of the model by means of the shaft and bearing. In the illustration a bent-nail bearing is shown lashed to the frame. The shaft is passed through the hub with its pro-

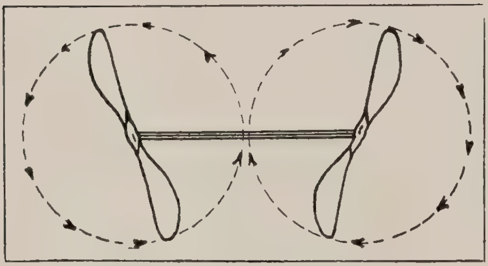


Figure 50. Twin Propeller Arrangement. Note that the propellers revolve upward and outward from the center.

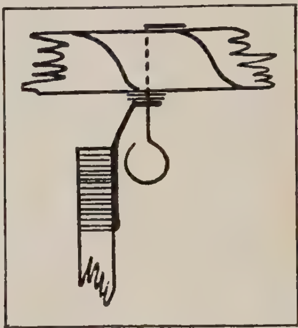


Figure 51. How Propeller Is Fastened to Bent Bearing

jecting end bent over and Ambroided to the hub. If necessary it may be reinforced by indenting the bend and lashing. Two or three washers are slipped on the shaft which is then passed through the bearing. Finally the propeller is revolved to make sure it runs true.

If the propeller is used on a pusher model, the hook of the shaft will be on the convex side of the blade; if on a tractor, it will be on the concave side. Figure 50 shows the most efficient method of placing propellers on a twin-pusher model. It is assumed that the propellers have curved entering edges and that the model is being observed from the rear. The propellers should turn upward and outward to give best results. In the case of twin propellers, both should balance in weight and have similar blade curvatures; this will insure that, other things being equal, the model will fly straight.

Some model designs call for 3- and 4-bladed propellers. A three-bladed one is made by carving three identical blades

with a slight hub projection, and fitting these into a hub which has three slots 120 degrees apart. Figure 52 illustrates this. The hub may be either triangular or round, but after the blades have been fastened in their slots with Ambroid, the

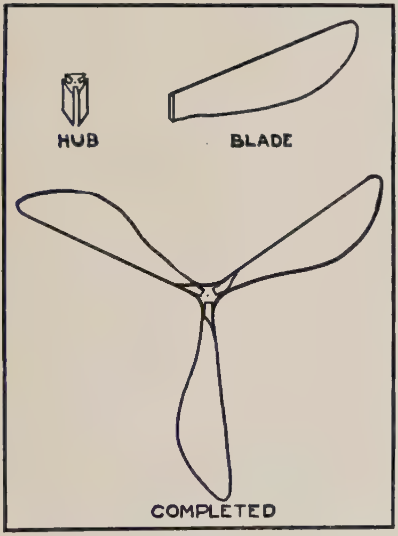


Figure 52. A Three-Bladed Propeller

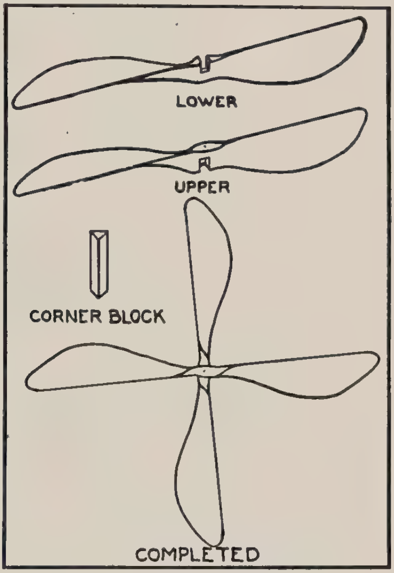


Figure 53. A Four-Bladed Propeller

hub should be carved to shape into the blades. Be sure all blades rotate in the same track and that the balance is perfect.

A 4-bladed propeller is made by fitting two 2-bladed props together with a halved-together T joint at their hubs, as shown in Figure 53. Each half should be exactly similar with the exception of the hub cuts which should be made respectively in the upper and lower sides and of the width of the hub itself. Ambroid is used in the joint, and if necessary, it may be strengthened by Ambroiding little corner blocks in the hub angles. Finally, balance the blades and make sure that the hub hole is continuous.

Although most modelmakers use carved propellers, some prefer bent-wood propellers as they are easy to make and are light. Figure 54 shows how they are made. First, a press is made consisting of a base *A,* a block with a slit in it *B,* a

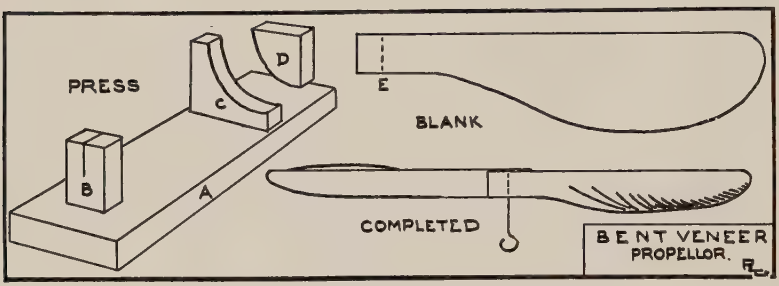


Figure 54. A Bent-Wood Propeller

rectangular block with a curve cut out of one corner *C,* and the piece cut from *C,* shown at *D.* The size of the press will depend on the size of the propeller. Blocks *B* and *C* are fastened to the base by nails or screws up through the bottom. The blank for one blade is cut to the pattern shown and a small cut is filed across the hub at *E.* This blank is made of veneer, which may be purchased from lumber yards or obtained from fruit crates, baskets, boxes, etc. It should be about 1/16 of an inch in thickness. The blank is placed in a pan of water and boiled for half an hour to soften it, then it is put in the press with its hub in the slot and the blade in the curve of *C* held down by *D* which is lashed in place. It should remain in the press about 24 hours; it will then keep its shape after removal. A second blade is made in the same way. The process may be speeded by using two presses. Finally the two hubs are placed together as shown in the completed view, where they are fastened with Ambroid and lashing, and the shaft is passed through the hole made by the joining of the two file cuts.

Another form of bent-wood propeller may be made by taking a single piece of veneer as long as the complete propeller, with its two blades shaped like the illustration for the previous type, and bending each blade over a flame as is done

Figure 55. Shaft

with bamboo. This method requires expert work to insure accuracy. The shaft is attached as shown in Figure 55.

As the modelmaker progresses, he will find that propellers are a very important part of his product. He will learn that different models require different propellers and that a propeller that may produce records on one model will not do for another. Inversely speaking, a model that will not fly with one type of propeller may perform splendidly with another type, so it behooves each constructor to study and experiment in order to obtain the best results.

CHAPTER VI

HOW TO MAKE MODEL AIRCRAFT FITTINGS

In the construction of model aircraft, various fittings are used to join the parts together and to operate the mechanism. It is necessary that they be light but strong, so they are made of wire, thin sheet metal, tubing, etc. Much of the material can be found in the "junk box" that every boy possesses; a few items must be purchased from a hardware store, and for the constructor whose time is limited, the necessary parts can be purchased from model supply houses.

Figure 56 shows a group of fittings such as are employed on scientific models. Number 1, illustrates how a propeller shaft bearing is made. A small nail, known as No. 16, 1½ inches, has its head flattened by a few blows of a hammer while the nail is held on iron. Then, in the center of the flattened portion a dent is made with a center-punch, and a hole bored with a drill of sufficient size to receive the shaft to be used. For the average shaft, a No. 60 drill will do. If the model has a back brace, like that described in Chapter VIII, the nail can be cut off, flattened a little to prevent its rolling, and lashed to the brace with the head projecting. If the model is open at the rear, like the P.E.G.-54 (see Chapter X), the nail is bent as shown in Figure 57-*A*.

A similar bearing can be made from wire by forming an eye in the center of a piece of piano wire (No. 10), and bending the ends back as shown at *B*. A small piece of tubing makes a neat and efficient bearing. It may be wired on to the back brace as at *C*, but it can be made more substantial if a washer is slipped over it and soldered as at *D*.

The most satisfactory use of tubing for bearings, however, is in connection with a strip of metal as at *E*. A piece of thin metal (tin, brass, copper, or phospher-bronze), 2 x ¼ inches, is tinned with solder for ½ inch at its center and

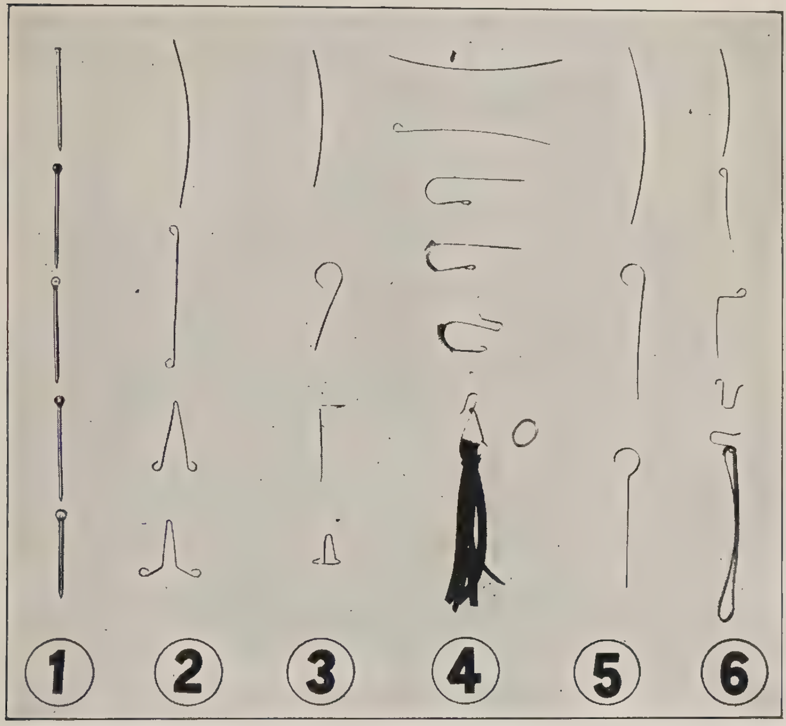


Figure 56. The Making of Fittings Used on Scientific Models

then bent around a nail which is slightly less in diameter than the tubing. If the pliers are clamped close to the nail, the metal will fit snugly. The tubing should be of copper or brass, ⅜ inch in length, about 1/16 inch in diameter, with a hole large enough to receive the shaft. It should now be tinned and slipped into the bend of the strip. Hold them in a flame for a moment with the tube downward until you see

the solder on each part run together, then withdraw and cool. The illustration shows how it will appear when completed. These are called "Comet" bearings because of their shape; they are used on the ends of back braces as for the "Humming Bird" (see Chapter IX), and lashed in place.

F shows a strip bearing made from aluminum ¼ x 3 x 1/32 inches. Holes are drilled for the screws and shaft, and

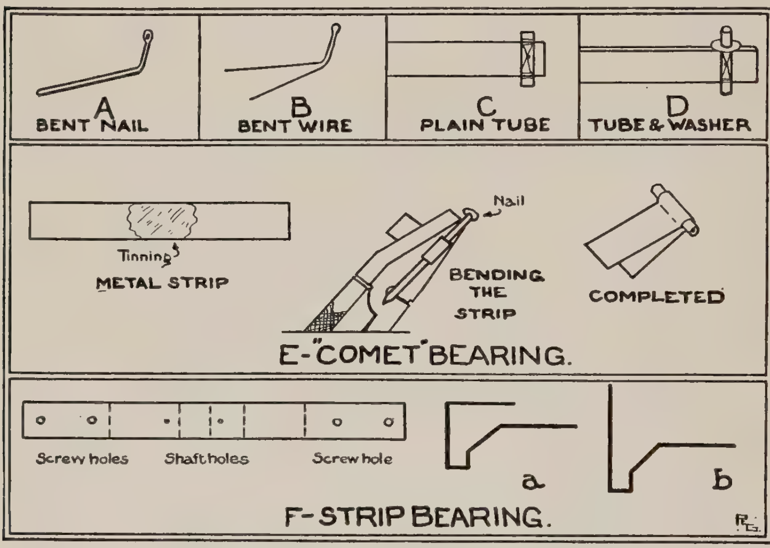


Figure 57

bends are made where indicated; *a* shows how it is bent for use on a single stick and *b* for a juncture of two sticks as in a rectangular frame.

In the above paragraphs and in other places throughout this book, mention is made of soldering which is such a useful accomplishment that every modelmaker should acquire it. The two essentials are proper equipment and cleanliness. Figure 58 shows a good soldering set where *A* is the soldering-iron, *B* the abrasives, *C* a can of soldering paste, *D* a bottle of "killed

acid," and *E* the solder. The soldering-iron has a wooden handle, iron shaft and copper bit. It can be purchased at any hardware store; one with a bit about 2 inches in length will do nicely for model work. The abrasives are sandpaper,

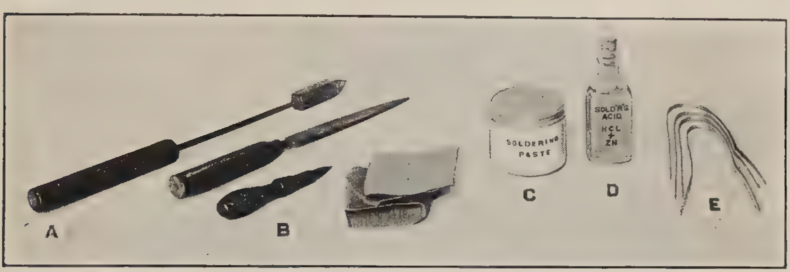


Figure 58. Soldering Equipment

emery paper, a small file, and a scraper made by grinding down an old three-cornered file to a three-sided tapering point. Soldering paste is procurable at hardware stores; its duty is to prevent the cleaned surfaces from oxidizing. The "killed acid" is muriatic acid "killed" by dropping into it some small pieces of zinc. An ounce of acid will be plenty and the zinc should be added until bubbles no longer are formed on it. Your druggist has the acid, while zinc can be obtained by cutting up the shell of an old dry battery. This liquid is used to clean the metal and will delight you with its ability to make the solder "stick."

The pieces of metal that are to be soldered must be scraped and polished clean; it is important to get right down to the shiny metal. Each of the surfaces are then rubbed with a thin coat of soldering paste. Meanwhile the soldering-iron has been heating over the kitchen gas range or other flame. Experience will teach you how hot it should get; it should be less than red-hot. Now, take it from the flame, file the nose of the copper bright, touch the four filed sides

with the acid and rub the solder over it. This is called "tinning." Next, apply the soldering-iron to the pieces to be joined; the solder will flow from the copper to the metal and spread over the joint. If more solder is needed, feed the copper from one of the sides and it will run to the tip and onto the metal. Sometimes objects are soldered together by sweating, that is, coating each surface with solder and holding them together in a flame while the solder on each melts together. The preliminary coating is also called "tinning."

The foregoing should enable anyone to do good work. If trouble is encountered by the solder showing a reluctance to flow onto the metal, use a touch of the acid to clean the surface of the metal, but after using acid in a job, clean it thoroughly to prevent corrosion. Tin, copper, brass, bronze, iron, and several other metals can be soldered as above, but aluminum requires special handling and for this the reader is referred to the use of special aluminum solders which are on the market, with directions for their use on the wrapper.

Nose-hooks and tail-hooks are fittings used for attaching the rubber motors to the frames. Figure 56-2 illustrates the method of forming a nose-hook from small piano wire (about No. 15). The hooks on this fitting are too small for holding the rubber and are meant to hold an S-hook (Figure 56-*4*) which in turn holds the rubber. This facilitates winding through the use of a geared winder, described in Chapter XIII. For models powered with a single propeller in front, a tail-hook of the type shown in Figure 59-*A* is usually made to hold the rubbers. For the smaller models, the hook may be large enough to accommodate the strands, but for the larger models which require more winding an S-hook should intervene, so the tail-hook loop can be smaller. A type for use in an enclosed fuselage is shown at *B*, where the projecting end is reinserted in the wood to fasten it. A threaded

tail-hook is shown in Figure 60. The modelmaker's ingenuity will suggest the type of hook to be employed in accordance with the model under construction.

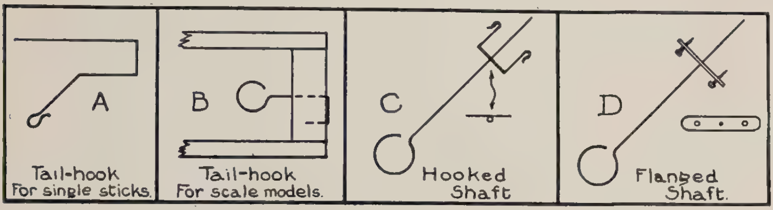


Figure 59

Figure 56-*3* illustrates the making of a "can." These are very useful fittings which are fastened to the frame of a model where the rubber motors pass, and serve to distribute the

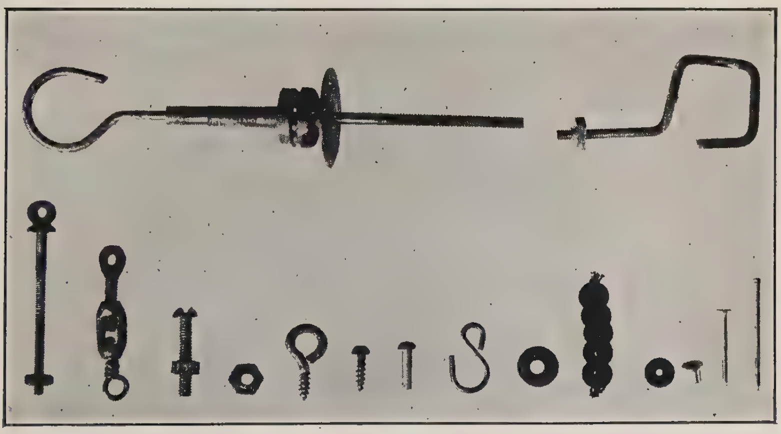


Figure 60. Purchased Fittings

tension when the model is wound. Similar fittings are used on fishing rods, and when a fish is hooked the pull does not come only on the rod-end and reel which would bend it like a bow, but is divided into as many sections as there are cans. So it is with a model airplane, and in these days when light

construction is essential to worth-while flights, every item that conserves strength is indispensable. These are called "cans" because the first ones were made of sheet metal and looked like a can. Later ones were made of bamboo, but now wire is the best usage. The type illustrated is the best for general use. It is easily made and has an opening through which the rubbers can be removed to prevent abrasion when winding. Special models may require special types, but where such a condition occurs in the models described in this book, the advocated "can" is included in the description.

Figure 56-*4* illustrates the making of an S-hook. The little eye is turned in one end and is hooked onto the side to prevent the pull of the rubbers from opening the hook. This feature permits the use of lighter wire than would be required with an open hook. A short piece of rubber tubing is used so the rubbers will not be cut by the wire. This is purchasable from rubber stores and oculists as spectacle tubing, or may be cut from rubber insulated telephone wire. The little rubber band shown is used to keep the rubber loops snug to the hook. It is known as an "election" rubber band.

Figure 56-*5* shows a shaft made from piano wire, about No. 15. It is important that the hook be turned back as shown at the bottom so the pull of the rubbers will be centralized. Test the trueness of the hook by twirling the shaft between the thumb and finger and correcting the bend until the hook revolves like a ring. This type of shaft is retained in the propeller by bending the projecting end over and Ambroiding or lashing in place. This is sufficient for general purposes, but for the modelmaker of an experimental nature, the shaft shown in Figure 59-*C*, which has a wire twisted about it with hooks and soldered in place, will enable various propellers to be tested. The twisted wire should be about an inch and a quarter in length, the part at right angles to the

shaft being equal to the propeller hub width. After the propeller is slipped on, it is retained by a wire or rubber band passing over the hub and fastened to the hooks. The same illustration, Sketch *D*, shows a flanged shaft with a plate

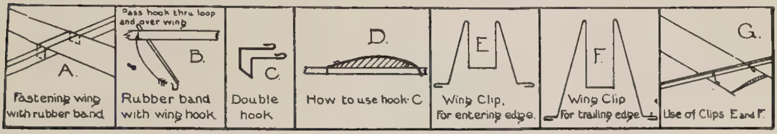


Figure 61

soldered to the shaft and having holes for screws which secure the plate to the hub. This type is used on many scale models.

Figure 60 shows a ball-bearing propeller shaft, which is purchasable at regular model supply houses, or can be made

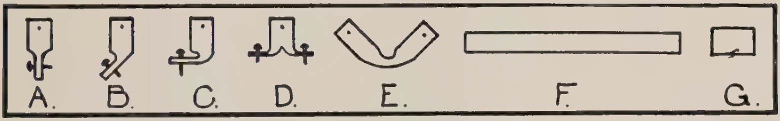


Figure 62. Tube Fittings

by a modelmaker equipped with a lathe. This type is not used on scientific models because of its weight, but for elaborate scale models it is a nice addition. The same photo shows other purchasable fittings: left to right, an eye-bolt, turnbuckle (for tightening wires), bolt, nut, screw-eye, screw, rivet, S-hook and washer. Next is a string of dress spangles such as can be found in any notion store; these make excellent washers. The little eyelet adjacent to the single spangle is useful for insertion on a shaft to space the propeller further from the bearing. The nails are size 20, which is best for model work.

Figure 56-*6* shows a little hook which, with a rubber band,

is used for fastening wings to frames. Most wings are held on by passing them under the open loops of a rubber band which goes under the stick as in Figure 61-*A*, but the model can be more easily taken down and assembled if these little

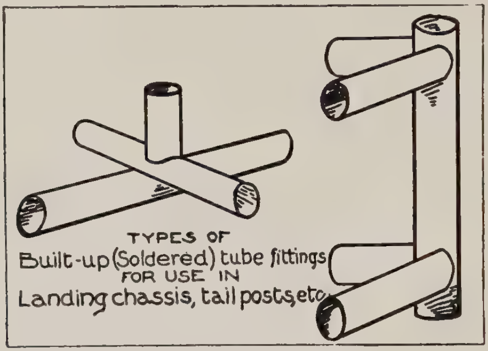


Figure 63

hooks are used as shown in *B*. *C* shows another wing-hook which is particularly useful on single stick models as it holds the wing rigidly. *D* illustrates its use. *E* and *F* are clips fastened to the spars of a wing at its center, *E* being on the entering edge and *F* on the trailing edge. By their use, as shown at *G*, the wing can be easily attached and adjusted; because the front clip is higher than the rear one, the wing is given the necessary angle of incidence for flight. All of these wing hooks are made of light wire, preferably piano wire No. 10.

Small, thin-walled copper, brass or aluminum tubing can be made into useful fittings for attaching wings, struts, etc. Figure 62 illustrates a number of these, wherein *A* is a straight socket fitting and *B* and *C* are angled sockets. They are made by cutting off a short piece of tube, and pinching one end in a vise, drilling the pinched end to take a screw and drilling the socket for a nail or screw to retain the strut held therein. *D*

is cut up from the bottom with a hack-saw and has the two halves turned out for lugs. *E* is a longer piece bent in the center with a pair of round-nosed pliers and used in the chassis of a model to secure the struts. The axle can be soldered in its bend, or fastened there with a rubber band to give a shock-absorbing effect. *F* is a sleeve made of a straight piece of tubing and used for piecing long spars together. Sleeves make the model portable in that the wings, etc., may be pulled apart. Square sleeves can be bent from sheet metal as shown at *G*.

The foregoing descriptions embrace all necessary fittings. Some modelmakers who may care to add various devices can improvise them by the use of wire, sheet metal, etc., but every reader should endeavor to make his flying models as light as possible and avoid the use of material which, although it may add to the appearance, will make it undesirably heavy and detract from the flying ability. Models intended for exhibition only can have, of course, as many fittings as the design includes and ingenuity can produce. Wheels and floats are described in Chapter XV, and Chapter XVII suggests many special fittings for scale models.

CHAPTER VII

THE "SIZZLEFOOT"

The "Sizzlefoot" type of model is easily made and flies well. It derived its peculiar name from the fact that it has a single-stick fuselage and a V-shaped tail. The appellation "single-stick, V-tail" was soon shortened to S.S.V.T. and ultimately to "Sizzlefoot." The fuselage consists of a tapering stick; the tail is made by covering the frame formed by the back brace and its braces. It is a good model for the beginner and can be made from easily procured wood such as pine. The following material is required:

Wood:

Fuselage and Empennage:

1 straight-grained stick, 36 x 3/8 in. square
1 back brace, 1/4 x 1/16 x 8 in.
2 braces, 1/8 x 1/16 x 5-3/4 in.

Wing:

2 pieces, 24 x 1/8 x 1/16 in.
1 back edge, 7-3/4 x 1/8 x 1/16 in.
7 ribs, 4 x 1/8 x 1/16 in.
4 ribs, 5-1/2 x 1/8 x 1/16 in.

Propellers:

2, 8 x 1 x 3/4 in.

Metal:

2 small nails, No. 16, 1 in. long
2 wire shafts
4 washers or 2 beads
1 wing clip
2 S-hooks

1 nose-hook
1 spool No. 32 wire for binding

FABRIC:

1 sheet tissue paper or 1/4 yd. China silk
48 ft. 1/8-in. flat rubber thread
Silk thread for binding
1 3-in. rubber band

LIQUID:

Ambroid or glue for adhesive
2 oz. banana oil for surfacing

The first act in making a model after laying out the necessary material, is to make the various pieces of metal fittings

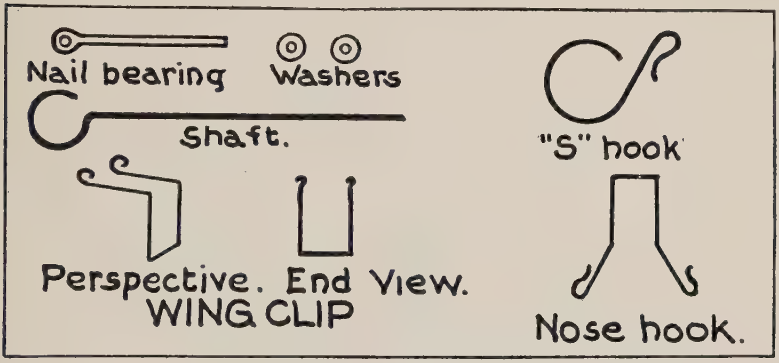


Figure 64. Metal Fittings

that are specified. The drawing, Figure 64, shows how each is shaped, and Chapter VI on Fittings describes each step that is necessary. The bearings are made by flattening one end of the nails and drilling therein a hole for the shaft, which is made of small wire, preferably piano wire No. 10, but it can be any other strong and small wire. The washers or beads are used on the shaft at the bearing to reduce friction. The use of the other fittings will be explained in proper order.

Plane the long fuselage stick from the center so that it tapers from ⅜ inch square to ¼ inch at the ends. To one

end lash the nose-hook; to the other end, at right angles, lash the back brace, having first bound the nail bearings to each

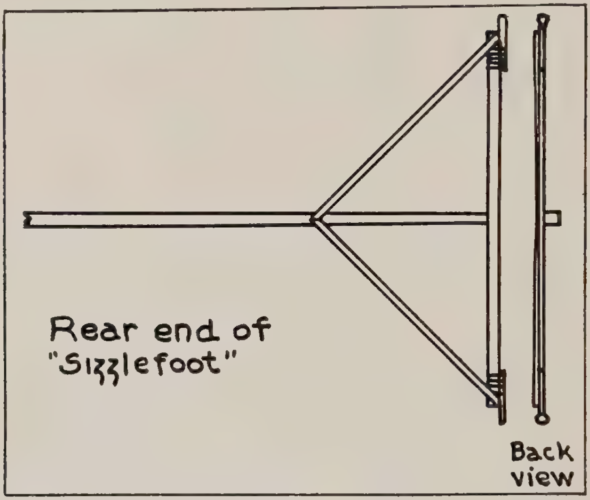


Figure 65

end of it, as shown in Figure 65. The side braces are next bound in place, extending from a point 4 inches ahead of the

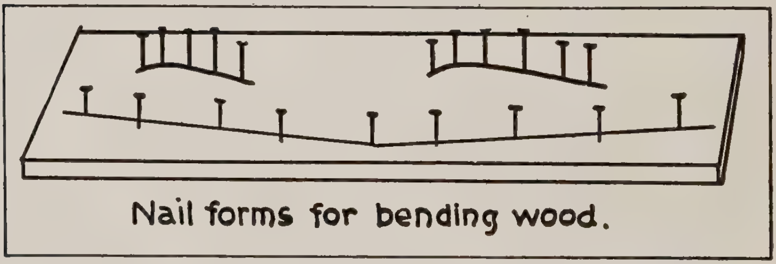


Figure 66

back brace to the ends of the brace itself. In all lashings, be careful not to make the work bulky with too much thread. Use Ambroid between the wood and enough thread, tightly wrapped, to make a secure joint, then put a light coat of Ambroid over the wrapping.

Many years ago students of aeronautics found that a wing that is curved will lift better than one that is flat, and that a wing slightly bent laterally is more stable than one made

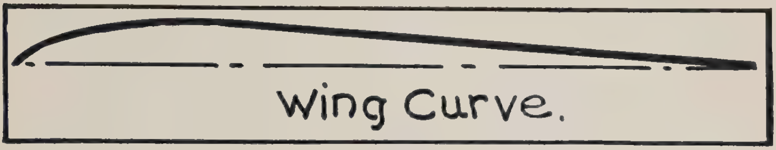


Figure 67

straight, so we will include both of these improvements in our model. The necessary bending will be done by boiling or steaming the wood, then allowing it to dry in a suitable form.

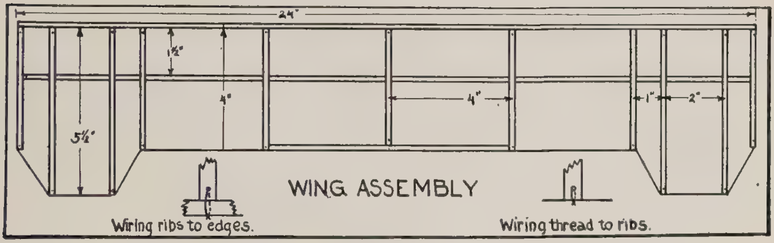


Figure 68

Use a broad flat pan like a pie plate, filling it nearly full of water. Put the ribs in it and set it on a fire. Wrap the long wing sticks in a wet, hot cloth, and lay the bundle with its center over the pan. Put a lid over this and let it boil half an hour. While it is boiling prepare the forms. In a piece of wood about 3 feet in length by 6 inches in width, drive nails as shown in Figure 66, the curve being like Figure 67, and when the wood is soft from boiling, lay the ribs in the curved form and the long sticks in the angled form, using other nails to keep the wood properly in place. Let the wood dry 24 hours and when taken from the forms it will retain the shape.

These pieces are assembled as shown in Figure 68, using one long piece for the entering edge and the other for a spar 1½ inches distant. First, the ribs are lashed to the spar in the positions indicated, and with the front projecting 1½ inches. Next, the front edge is wired on by drilling a hole in the end of each rib and threading wire through it and fastening over the edge, using Ambroid for adhesive. In a similar manner the small central piece of back edge is wired in place. Finally a thread trailing edge is wired to the ribs, using Ambroid for additional security. Cover the framework on the top side with tissue paper or silk, first painting the center rib with an adhesive made by thinning Ambroid with banana oil, and fastening thereto the center of a piece of fabric slightly larger than the frame. Continue with each panel of the wing, stretching the fabric tightly and pulling taut lengthwise rather than crosswise in order to preserve the proper wing curvature. Fold the fabric over the thread and fasten down. When dry, coat the wing with banana oil in order to shrink the fabric and surface it. This completes the wing.

Next, make the propellers, using the method described in Chapter V, namely, by drawing diagonals on the blocks and sawing to these lines, leaving a slight hub; then drilling the hub to fit the shaft and carving the blanks, one a right-handed and the other a left-handed propeller; finally rounding off the tips and accurately balancing each blade with the other. Put the right-handed propeller shaft through the right-hand bearing, and the other through the left-hand one (looking toward the nose); divide the rubber thread into two pieces, and form each piece into an 8-strand hank. Put an S-hook into one end of each, attach the S-hooks to the nose-hook and the other end of each hank to its propeller shaft.

The wing clip shown in Figure 64 has the upright rectangular portion to fit the fuselage stick. The reason for

making the small stick insert in the trailing edge of the wing is now apparent; it was done to secure a firm hold for the wing clip. The wing is attached to the fuselage stick by putting the clip over the rear edge and hooking a rubber band from

Figure 69. The "Sizzlefoot" Completed

one clip-hook over the wing under the stick in front and back over the wing to the other clip-hook. In this way the rubber at the front acts as a buffer in the event of a bad landing, allowing the wing to slip forward rather than be broken by the shock. Before launching, put a $\frac{1}{8}$-inch high piece of wood under the entering edge to give the wing an angle of incidence. The finished model is shown in the photograph (Figure 69).

Test the balance of the model by gliding it, holding it in front of you by the propellers and thrusting it gently from you. If it noses down, move the wing forward; if it noses up move the wing slightly backward until the model makes a nice even glide, then it is ready for flight. Select a large, clear field for flight; wind each propeller about 800 times, preferably using the winder described in Chapter XIII. Face the wind; hold the model above the head and well back; incline the nose up slightly and thrust forward.

The original model of this type constructed by Fleming-Williams of England about 1910, made the then astonishingly

long flight of over 1,000 feet and as the model described embodies several improvements over the original, you should be able to get very satisfying flights from it.

This model is easy to make but is liable to distortion when tightly wound as the rubbers tend to bow the fuselage stick. In the next model this feature is overcome by using an A-shaped fuselage and putting rings or cans along the sides which keep the rubbers from exerting their pull over a too widely separated section. If the back braces bend too low under tension, put additional diagonal braces to the under side of the stick.

CHAPTER VIII

THE MONOWING

The "monowing" model (Figure 70) is so named because it requires the construction of only one wing, the other being formed by covering a section of the frame between the two rearmost braces. In some aspects it is similar to the "Sizzle-foot," described in the previous chapter, but it is an improvement upon the former in that it is stronger and provides more rigid support for the wing. The model is easily made and flies very well. The plans can be carried out in either a light domestic wood such as pine or spruce, or in balsa wood. The latter affords lighter construction, but the beginner in model aeronautics may prefer to use the stronger woods in order that the model may better sustain the rough landings it may make while its builder is learning how to handle it. The following may be said for balsa wood construction, however. Although it is weaker than spruce and similar woods, nevertheless the finished model is so light that in event of a hard landing, the model does not come down so heavily as it would if made of spruce. After all, model airplanes are built to fly, not to operate on the land, and if they are built lightly they will waft so gently to the ground after every flight that damage will not result.

The following material is needed for the "Monowing" (see Figure 71):

Wood:

Fuselage:

2 longerons, 3/8 x 1/8 x 32 in.

1 back brace, 1/4 x 1/16 x 7-5/8 in.
1 piece of bamboo pole, 6 in.

Wing:

1 spar, 1/4 x 1/16 x 17 in.
2 wing edges, 1/8 x 1/16 x 17 in.
11 ribs, 4 x 1/2 x 1/16 in.

Propellers:

2, 7-1/2 x 1 x 3/4 in.

METAL:

2 propeller bearings (*g*)
2 shafts (*h*)
4 washers (*h*)
4 "cans" or rubber guides (*i*)
2 wing retaining clips (*k*)
2 S-hooks (*o*)
1 nose-hook (*p*)

FABRIC:

1 sheet tissue paper for covering
32 ft. of 1/8 in. flat rubber thread
Silk thread for binding
2, 3-in. rubber bands
4 "election" rubber bands

LIQUID:

Ambroid cement for adhesive
2 oz. banana oil or dope for surfacing

Before starting the woodwork, make up the metal parts so they will be ready as required. Reference to Chapter VI on Fittings will enable the builder to form each part; in fact, the photograph (Figure 56) shows each item in detail. Next make a full-sized drawing of the frame (Figure 70-*1*). Draw a triangle 32 inches in length with a base 7 inches in width, drawing in the various braces shown in the accompanying cut. Brace *b* is 5 inches from the back; *c* is 10 inches from the back and is 4 inches wide; *d* is 5 inches from *c* and is also 4 inches wide; the small straight brace is 6 inches from the

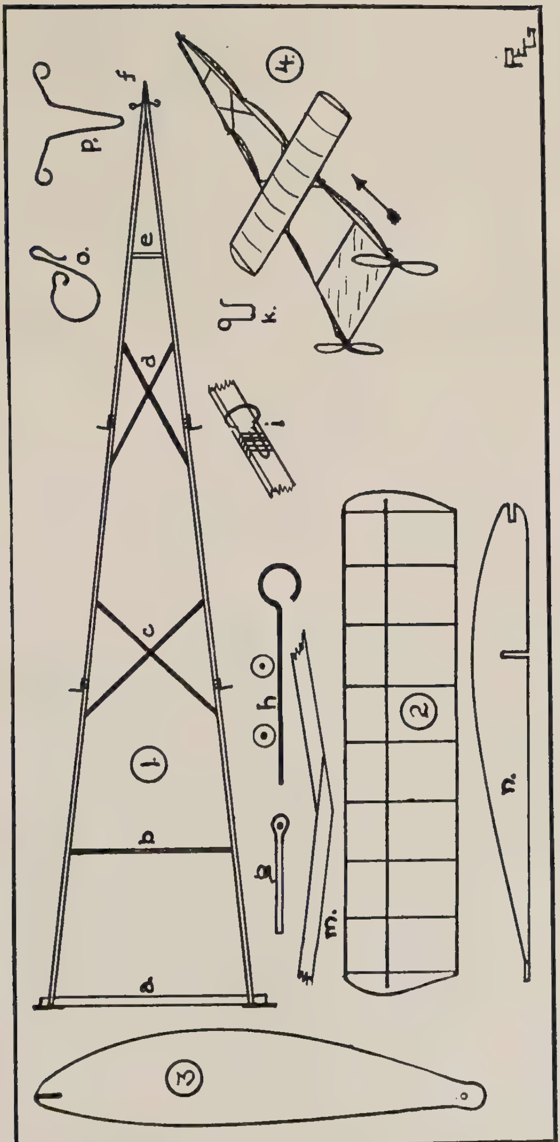


Figure 70. The Monowing

Figure 71. Material for the "Monowing"—showing wooden parts, bamboo, rubber bands and tubing, nails for bearings, piano wire for fittings, Ambroid, banana oil, etc.

point. The reason for making the drawing is that the parts can be better cut and fitted when compared with a full-sized layout.

Figure 72. Lashing Bearings and Making Brace Slits

Having drawn your plan, proceed with the construction. Sandpaper each longeron smoothly, rounding off the edges; cut one end of each to a chisel-like taper as shown in the photo-

graph (Figure 72). This taper should be of such length that when the two cut faces are pinched together the open ends of the longerons will be 6 3/4 inches apart across the inside. When this is correctly done, apply Ambroid to each cut face, put them together, fit the nose-hook over the point as shown in Figure 72, and bind neatly. While this is drying, make the back brace. Sandpaper it smoothly and to each end wrap a bearing as shown, rubbing Ambroid into the lashing. Now hold the open ends of the frame together, make sure they are even, and cut in each a step large enough for the back brace. Ambroid and lash the back brace therein.

Braces *b, c, d* and *e* are made of bamboo split from the short piece of pole; they all have a section of 3/32 x 1/32 inch. Brace *e* is 1 3/8 inches. It is fastened in place by first making a slit in the center of the longerons, 6 inches from the nose, as shown in the photograph (Figure 72), then sharpening the ends of the brace to a chisel-like edge, applying Ambroid to each piece, and putting the brace in place. Cross brace *d* is made of two 5-inch pieces similarly fastened, then lashed in the center; *c* is made of two 6-inch pieces, and *b* is 6 inches in length and parallel to *a*. If the braces fit the slits properly and the Ambroid is correctly used, no lashing will be necessary in these joints. While placing the braces, from time to time lay the frame upon the full-sized drawing, to be sure that you are working correctly and are keeping the sides straight. Finally, sight along the sides, and if they are not straight, make them so by pushing the braces in or out before the Ambroid has set. Trim off any points of the braces which may protrude outside.

The "cans" are very necessary to distribute the strain of the rubbers. They are lashed to the sides of the frame between the cross braces and the openings are all on the same side as the back brace. This side is to be the top. The frame,

if of balsa, should now be painted with banana oil to strengthen it.

The wing construction (Figure 70-*2*) is made clearer by reference to Figure 73 wherein *1* shows a pile of thin wooden slats from which the ribs are to be cut. A single slat is shown at *2*. The rib outline shown at *n* in Figure 70, the main drawing, is to be copied 4 inches long on paper. The paper is then pasted to a piece of tin which is cut out to the rib shape for use as a template or pattern, illustrated in Figure 73-*3*. This is laid over each of the eleven slats that appear then like *4*. Each rib must have a slot in the nose for the front edge and in the bottom for the spar 1½ inch from the nose. These are easily put in by holding the ribs together and drawing a hacksaw blade across at the proper places as at *5*. To lighten the wing, it may have its ribs bored out. This is done by pulling the eraser out of the ferrule on a pencil and spinning the metal tube around on the rib, cutting out a disc, just as the cook cuts biscuits out of dough.

The completed rib appears at *6*. This wing has been designed to have a slight upward angle or "dihedral" to give the model automatic stability. The angle is made by taking the spar *7* and cutting it in the center as shown at *8*, then rejoining as at *9*, and Ambroiding and lashing the joint. The angle should be such that the ends of the spar will be 1 inch higher than the center. The wing edges *10* must have a similar angle, but as these are to be bent in the sides and not the edges, the bend can be imparted by holding them above a flame until the heat softens the fibers, then bent to the proper angle and held until they cool. Steam from a teakettle spout may be substituted for the flame.

With the parts finished, the wing can next be assembled. The ribs being equidistant, are Ambroided to the spar by means of the slot in the bottom. The outer ribs are ¼ inch

from the end of the spar. The front edge is now slipped into each nose slot and Ambroided therein. To fasten the back edge, lay the frame upon a board and stick several pins along the front edge. Put a touch of Ambroid on the back of each

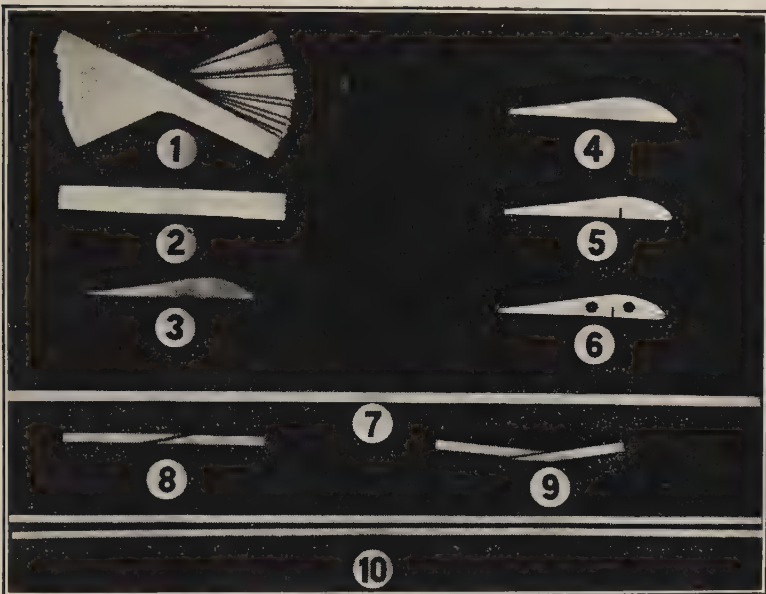
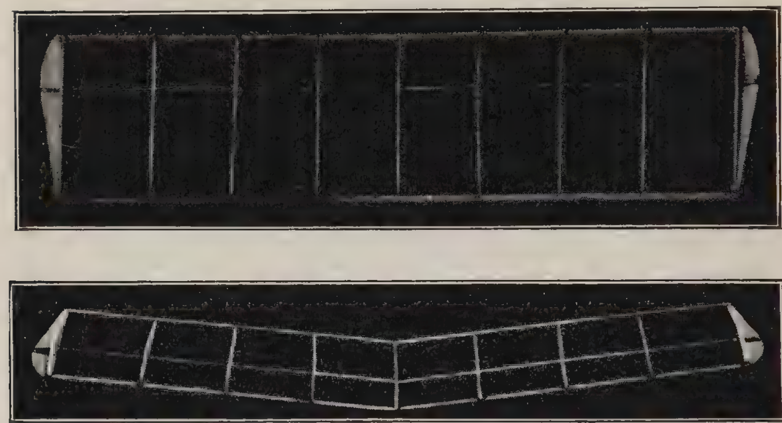


Figure 73. Wing Construction

rib, bring the rear edge up to the ribs and stick some more pins into the board so they will hold the back edge in place until the Ambroid is dry. The wing ends are made by applying Ambroid to the bottom of the two remaining ribs and to the bottom slot therein, and fastening the ribs horizontally to the end ribs, putting the slot in the spar. The completed wing frame is illustrated in the next two photographs (Figures 74 and 75).

Cover the wing with light tissue paper. Attach it to the bottom first by cutting a piece of paper slightly larger than

the frame, and beginning at the center, paint one panel with banana oil and fasten the paper on it. The banana oil should be a good adhesive for covering, but if too thin, pour some out and let it evaporate awhile to thicken, when it will adhere



Figures 74 and 75. The Wing Frame

better. Stretch the paper tightly in place and proceed outward from the center; when all panels are covered and dried, trim off the excess paper and paint the whole covered surface with thin banana oil, thus making the paper shrink and glazing the surface. As shown in the next photograph (Figure 76), where the wing is illustrated with the bottom all covered, the top is to be covered in two pieces, to avoid wrinkles in the center. One panel is covered at a time and the paper is stretched in place, pulling it especially taut lengthwise of the wing, to preserve the correct wing shape. Trim with a ¼-inch margin which is folded over and doped to the bottom edge. Dope the covered top with thin banana oil. Also cover and dope the space in the fuselage between the two back braces.

The propellers have the blade outline shown in the drawing

(Figure 70) at *3*. They are carved as described in Chapter V. When finished they are equipped with shafts and washers and assembled on the frame through the nail bearings. The rub-

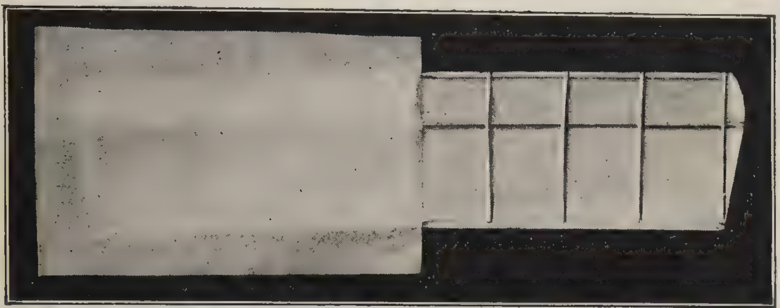


Figure 76. Covering the Wing

ber motors are made by cutting the 32 feet of rubber thread into two pieces, and looping each piece into six strands, tying the ends of each loop together with a square knot. Each hank

Figure 77. The Wing Completed

has its ends gathered together with an election band and in one end of each an S-hook is inserted. Assemble the power plant by attaching the S-hooks to the nose-hook, reeving the motors through the cans and hooking onto the shafts. The propellers should be placed to revolve outward and push air away from the model.

Two little hooks are made as shown in Figure 70 *k*, being

described in detail in Figure 56 where they are shown with a 3-inch rubber attached. The rubber is looped to the longeron by laying the loop under the longeron and carrying the hook over the longeron and through the loop, then pulling tight. This is done with each hook at a point just in front of cross brace *c*,

Figure 78. Launching the Model

then the wing is laid in back of the rubbers, the hooks are carried over the wing and attached to the longerons in rear of the wing, thus holding it in place (Figure 70-*4*). This is approximately the proper place for the wing but it may be moved forward or backward to balance the model. In order to give the wing an angle of attack, a short piece of wood, the size of a match, is inserted under the leading edge of the wing on each longeron.

Flight. To insure that the model is properly balanced, glide it several times by holding it over the head by the pro-

pellers and thrusting it gently from you. If it dives abruptly move the wing forward; if it noses up and stalls, move the wing backward or use smaller sticks under the wing edge. When a smooth glide is made the model is ready for flight. The propellers are to be wound about 800 turns each, in the direction opposite to that which they will revolve in flight. This is best done with a winder, described and shown in use in Chapter XIII.

A large field must be used for flights, as the model made by the author and shown by the photograph, has flown over 1,200 feet and remained in the air more than one minute. For launching, the model is held above the head as shown in Figure 78, inclined upward at a slight angle, and thrust forward. It should fly successfully and delight you with its performance. Adjustments for flights can be made as for the glides.

CHAPTER IX

THE "HUMMING BIRD"

The model illustrated by Figure 79 is easy to build and exceedingly rugged. Although somewhat heavy, it flies well. Its construction will introduce a new feature in model construction which is metal wing frames. The two models that have been described previously have resembled the familiar large machines in wing arrangement, that is, the large wing was in front of the smaller one. With this model we adopt the arrangement which most model fliers prefer, the "canard," with the small wing in front. It is so called because in French, the language which originated many aeronautical terms, *canard* means duck, and all boys will recall that a duck's large wings are at the rear and its head projects far forward similar to the little wing in the model we are about to make. In order to increase the ruggedness of this model, we will consider that the fuselage is to be made of pine or spruce, although balsa will give it better flying qualities at the expense of strength. The same plans may be employed for a similar lighter type by using bamboo frames in place of metal. The following material is necessary for its construction:

Wood:

2 longerons, 3/8 x 1/8 x 28 in.
2 braces (to form an X), 1/4 x 1/16 x 6 in.
1 brace, 1/4 x 1/16 x 1-3/4 in.
1 back brace, 1/4 x 1/16 x 6 in.
2 propeller blanks, 3/4 x 1-1/8 x 5-1/2 in.
1 incidence block, 1/4 x 1/4 x 1 in.

METAL:

2 "comet" type bearings
2 shafts to fit bearings
4 washers
2 cans
2 S-hooks
1 nose-hook
90 in. of 1/16-in. copper tubing or No. 18 piano wire, for wings

FABRIC:

1/4 yd. China silk
30 ft. rubber thread, 1/8 in. flat
4 pieces spectacle tubing
4 "election" rubber bands
3 3-in rubber bands
1 spool thread for sewing and binding

LIQUID:

Ambroid
Wing dope

Proceed with the construction as follows:

Fuselage. Having laid out the material as listed, make up the bearings, shafts, cans and hooks as explained in Chapter VI. Sandpaper the longerons smooth, rounding the corners slightly. Cut one end of each to a chisel-like taper of such inclination that when the cut faces are placed together the open end of the angle will be 5⅛ inches in width between the sticks. Put Ambroid on the faces to be joined, slip the nose-hook in place, and bind the joint neatly. Next, prepare the back brace by cutting the ends on a slant to conform with that taken by the fuselage sides. Put Ambroid on each end, slip the "comet" bearings thereon, and wrap them securely in place. Pinch the open ends of the frame together, and after making sure that the longerons are the same length, cut a step in the end of each. Lash the back brace into the step on each side, using Ambroid, and allowing the center of the bearing to

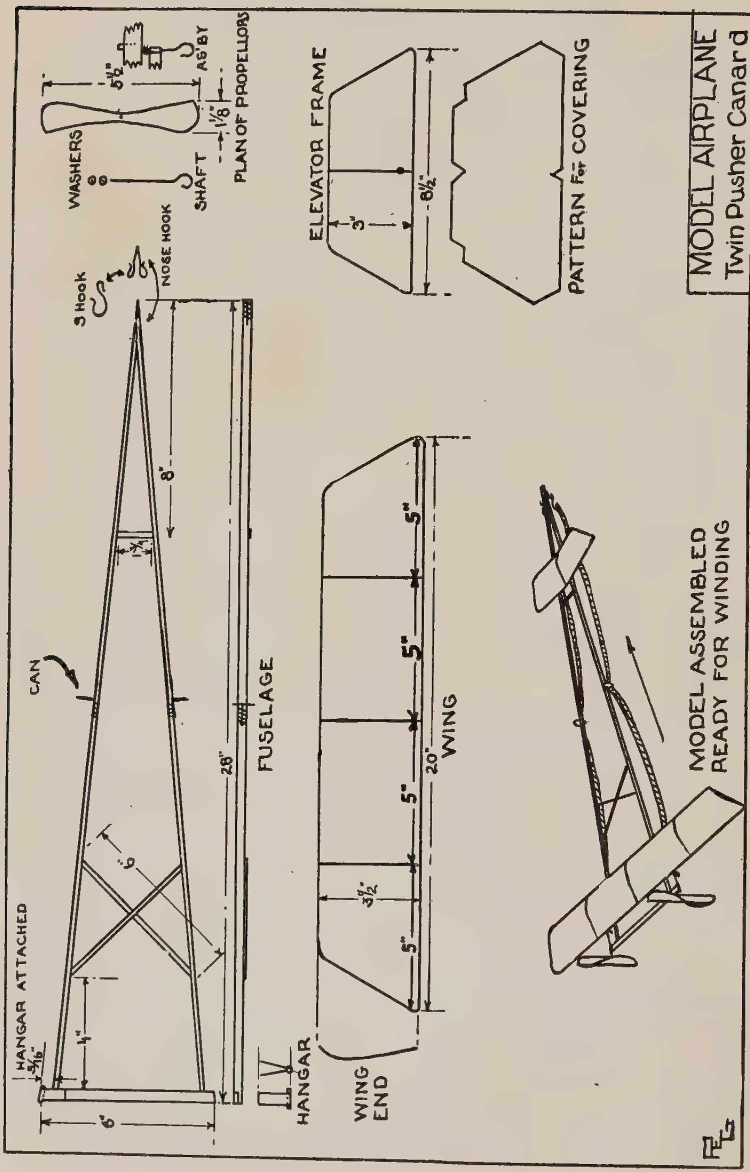


Figure 79. Plans for the "Humming Bird"

project 5/16 inch from the sides of the fuselage. Form an X brace with the pieces intended for that purpose and secure it 4 inches from the back brace, lashing it to the under side of the fuselage, that is, on the opposite side from the back brace. Trim the projecting ends away after the Ambroid has set. In a similar manner attach the front brace 8 inches from the nose. Bind the cans, using Ambroid and thread, in the center of the longerons.

Power Plant. The propellers are to be carved, one right- and one left-handed, as explained in Chapter V. The curved edges are to be the entering edges. Pass the shafts through the "comet" bearings, put two washers on each and put the shafts into the propeller hubs. They should be so arranged that the propellers turn outward to push air away from the fuselage. Bend the projecting end of the shafts over in a U shape and indent in the hubs. Rotate the propellers and make sure they turn true. Divide the 30 feet of rubber into two equal lengths. Tie the ends of each length together, forming two loops. Lay out each loop in an N shape, join the bends and ends of the N, and keep the hank from undoing by putting an election rubber band on each end. Put an S-hook on one end of each hank and hang it on the nose-hook. Pass the other end through the can and attach it to the shaft-hook.

Wings. With emery paper, shine up the copper tubing. In Chapter VI, in the instructions for soldering, cleanliness was stressed as vital to success, so make sure that all tarnish is removed from the tubing. Upon a large sheet of paper draw the outline of the wing and elevator as given in Figure 79, making them, of course, full size. Lay the tubing over the drawing and bend it to conform, keeping the shape flat. Draw 2 full-sized views of the wing end, detail view in the drawing,

making one 3½ inches for the wing, and one 3 inches for the elevator. The point of greatest curvature should be one-third of the distance from the front to back, and the top of the curve should be no more than ¼ inch from an imaginary

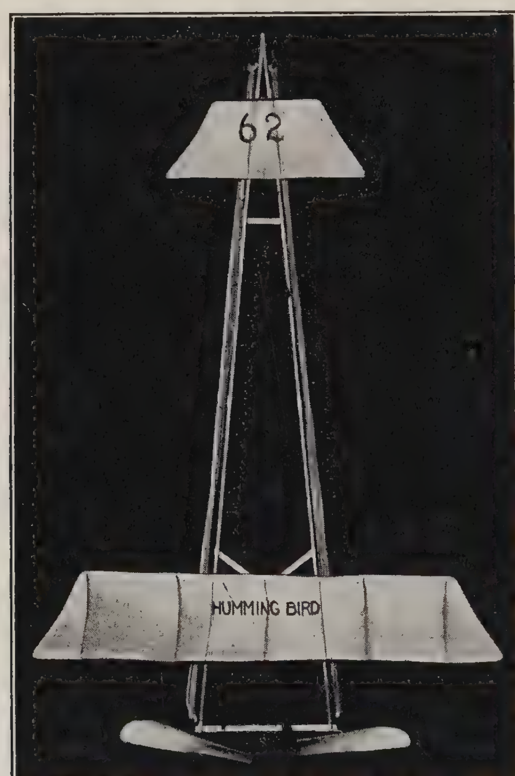


Figure 80. The "Humming Bird" Completed

line joining the ends. Make three of these lengths, called ribs, for the wing, and one for the elevator. Solder them in place. Next bend the ends of the wing and elevator to conform to the ribs, and finally bend each slightly upward from the center. This angle, known as dihedral, imparts stability, as explained in Chapter XIX.

Although China silk is recommended for this model, in order to increase its ruggedness, tissue paper may be used instead. If so, a pattern is formed by laying the wing on the paper and cutting it out, allowing a margin as shown in the

Figure 81. How to Hold the "Humming Bird" for Launching

drawing. The margin is then bent over the frame and glued in place. The covering should be on top of the frame. If silk is used, the pattern should be the same but the cloth is sewed on, as this results in a neater job. The thread is to be sewed through the silk and over the frame in a series of encircling stitches. It will help if the cloth is pinned on the frame and stretched tightly in place, before sewing is started. The fabric should be stretched lengthwise rather than across the frame,

as that preserves the curved section better. The sewing need not be carried over the ribs, except on the center ones, to keep the bend from pulling the fabric up. After covering, the fabric is painted with a coat of dope to make it airtight.

Assembly. Attach the wing and elevator to the frame with rubber bands, forming a loop around the longerons with the bands, and placing the wing under this loop, when it will be held in place by the tension. The method is the same as that used for the slingshot glider described in Chapter III. The wing should be about 2 inches from the back brace; the elevator should be about the same distance from the nose. Give the elevator an angle of incidence by placing the incidence block under its front edge. (See Figure 80.)

Flying. Wind each propeller a few times with the hands, just to take the slack out of the rubbers, and glide the model several times to test its balance. The model is held as shown in Figure 81 and thrust away. If it dives too steeply the elevator should be moved forward, if it climbs, stalls, and backs down, move the elevator backward. When good glides are made, the model is ready for flight. Wind the propellers in the proper direction, using the winder described in Chapter XIII, and storing about 600 turns in the rubbers. Make sure the wings are true and in line, hold the model as in the photograph, face the wind and thrust it vigorously away. Adjustments in flying are made as for glides. The model should fly well and delight you with its performance. The model illustrated in the photograph has flown 840 feet and remained in the air 40 seconds; yours may equal or better this achievement.

CHAPTER X

THE SCIENTIFIC MODEL AIRPLANE, P. E. G.-54

The model illustrated by Figure 82, about to be described, was made by the author in 1924, but is still in existence at the time this is written, a fact which argues well for its strong construction and good flying qualities. It was entered in the National Air Races at Philadelphia in 1926, and has often been used in exhibitions because it is always ready to make a good flight. When released it climbs rapidly to a high altitude then settles down to a long horizontal flight, terminating finally in a long glide. Its best record to date is slightly over a minute and a half.

In making this type you will gain useful experience in working bamboo, and when completed you will have a model that will be a source of much pleasure. It requires the following material.

WOOD:

Fuselage:

2 pieces balsa, 38 x 5/16 x 1/8 in., for longerons
2 pieces bamboo 10-1/2 x 1/8 x 3/64 in., for rear X-brace
2 pieces bamboo, 6-1/2 x 1/8 x 3/64 in., for center X-brace
2 pieces bamboo, 4-1/2 x 3/32 x 1/32 in., for front X-brace
1 piece bamboo, 1-1/2 x 3/32 x 1/32 in., for front brace

Wing:

1 piece pine, 25-1/2 x 1/4 x 1/16 in., for wing spar
2 pieces pine, 23 x 1/8 x 3/64 in., for wing edges
12 balsa ribs as per drawing
1 piece bamboo, 1/8 x 1/16 x 7 in., for wing ends

Elevator:

1 piece bamboo, 1/16 x 1/16 x 30 in., for elevator outline
1 piece bamboo, 3/8 x 1/16 x 3 in., for ribs

Propellers:

2, 8-1/2 in. diameter, I in. wide, and 3/4 in. thick

Metal:

2 shafts, No. 15 piano wire
2 nail bearings for propellers
6 cans, No. 10 piano wire
4 small washers
2 S-hooks, No. 15 piano wire
1 nose-hook, No. 15 piano wire

Fabric:

1/2 yd. China silk or one sheet tissue paper for wing covering
1 spool thread for sewing and binding
50 ft., 1/8 x 1/32 in., thread rubber

Liquid:

Ambroid for adhesive
Dope or banana oil for treating surfaces

First make the small metal fittings by reference to Chapter VI on Fittings. Draw the plan of the fuselage or frame upon a large piece of paper, putting in the braces, and use this drawing to lay the parts on as they are cut and fitted. This method insures correct placement and accurate alignment, as well as ease of construction. The longerons are first sandpapered smooth, then painted with dope to strengthen them, and when this has dried, an end of each is cut to a chisel-like bevel of such inclination that when the two cut faces are pinched together the other ends will spread apart 8 inches. Ambroid is applied to each face, then they are pinched together, the nose-hook is fitted over the apex and the nose is bound with the silk thread. The various pieces of bamboo for the braces are sandpapered smooth and rounded slightly;

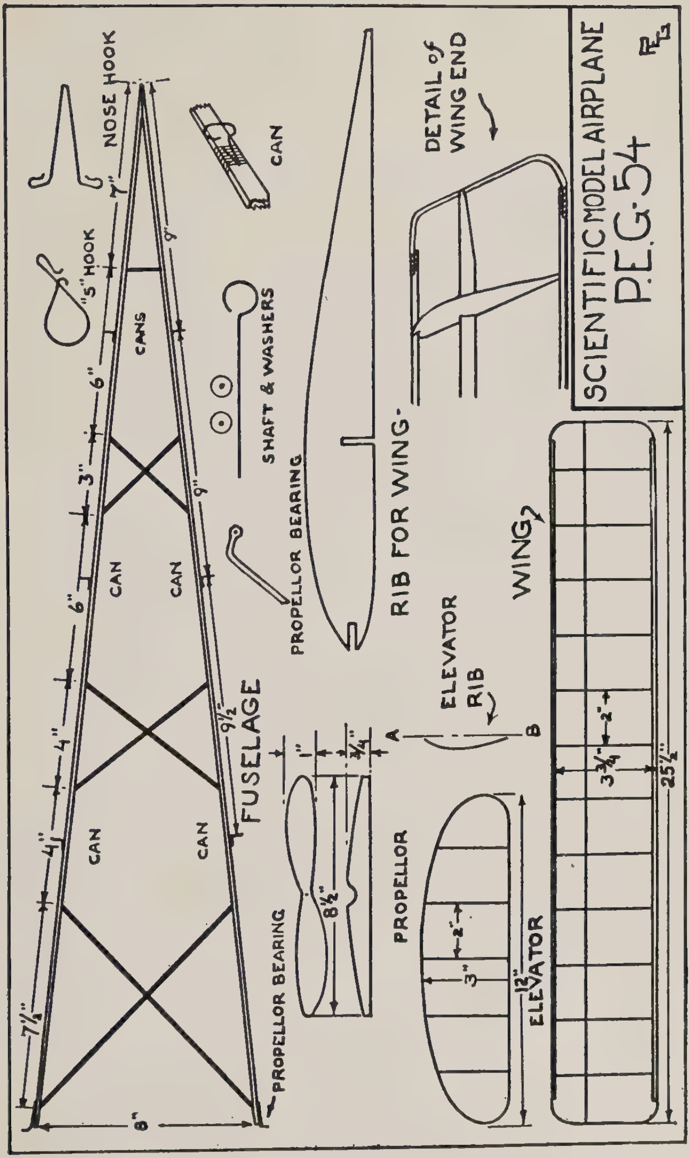

SCIENTIFIC MODEL AIRPLANE
P.E.G.-54
NOSE HOOK
"S" HOOK
CAN
CANS
SHAFT & WASHERS
PROPELLOR BEARING
RIB FOR WING-
DETAIL of WING END
WING
ELEVATOR RIB
FUSELAGE
PROPELLOR
PROPELLOR BEARING
ELEVATOR
A
B
7"
9"
6"
3"
4"
9½
7¼"
8"
8½"
1"
¾"
2"
3"
12"
3¾"
25½"

Figure 82

they are put into position by cutting the ends to a chisel-like point and inserting them in slits made in the sides of the longerons at the proper places, where they are Ambroided securely. Before they have set, pick up the fuselage and sight along its sides; if they are not straight, adjust the braces to make them so. When the Ambroid has dried, trim off any projections that may appear on the outside of the longerons. Bind on the propeller bearings at the rear of the model. It will be observed that these are of the bent type, differing from the straight type used on previous models, so when these are bound on, take several extra turns of thread at the bottom of the fitting to keep the pull of the rubbers from moving them down the frame. Bind on the cans in the places they are to occupy according to the drawing, making all of the openings in the cans face upward. The frame is now completed.

The wing ribs may be made either by slicing them from a block which has a profile like the drawing of the wing section, or by making a tin pattern like the drawing and laying it on thin slats of balsa, cutting the shape out with a sharp knife. No matter which method is used, the ribs should be uniform and all of the slots in them should be in line. The slots can be cut best by drawing a hack-saw blade across the ribs, in the proper place. Leaving a space of 1¾ inches on each end of the spar, the ribs are placed thereon and Ambroided in position, 2 inches apart. Be sure they line up true when you place this ladder-like frame on a flat surface. Put a little Ambroid in the nose slot of each rib and insert the front edge therein, lining up the ribs perpendicular to it and the spar. Next, stick some pins into a board in a straight line about 2 feet in length, using a half-dozen pins. Touch the back of each rib with Ambroid, lay the frame on the board, slide the entering edge up to the row of pins, place the trailing edge against the backs of the ribs and push more pins

into the board so they will press against the trailing edge to hold it in place until the Ambroid has set.

While this is drying, prepare the wing ends, using the bamboo piece 7 inches in length. Hold it above a candle

Figure 83. The Author Demonstrating the "P.E.G.–54" to a Group of Friends, including the Late Commander John Rodgers, of Pacific Flight Fame

flame as shown in Figure 40; by applying gentle pressure as the heat softens the fibers the wood can be bent to the proper shape, which in this instance should be a flattened curve with parallel ends 3¾ inches apart as shown in the drawing. Be careful not to burn the wood in the process because charring will cause weakness and make it unfit for use. When bent, carefully split the piece, making two wing ends, 1/16 inch square, of the same shape. These are fastened to the wing frame ends by cutting steps in the edges and a slot in the spar, then Ambroiding and binding the wing end therein. The square ends of the spar should be trimmed down at a long angle.

The wing frame is thus completed, and is ready for covering which is done by painting the edges on the bottom with

dope and laying on the fabric, stretching it tightly in place. The wing ends are next painted and the fabric fastened to them, stretching the fabric more tightly lengthwise of the wing rather than across it in order to preserve its proper section and prevent dips between the ribs. After trimming off the excess fabric and covering the whole surface with a weak solution of dope, the top of the wing is treated in a similar manner, excepting that a margin of ¼ inch is left all around and fastened to the bottom surface with dope. The top is then doped and the wing is left to dry on a flat surface.

The elevator is made entirely of bamboo. The bill of material specifies that a 30-inch length be used for the outline. It will be impossible to secure such a length without having to cut through one or more nodes of the bamboo, but this can be done without injury to the entire length if a knife is used carefully and a small plane employed to cut away irregularities and square up the split piece. The outline of the elevator is drawn upon a sheet of paper full size, then the long strip is held over a flame and carefully bent to shape, being frequently laid on the drawing to note the progress of the bending. The ends are beveled and bound together, using Ambroid also. The ⅜-inch short piece of bamboo is now bent to the shape shown at the side of the elevator drawing. This curve is highest one-third of the distance from the front and the greatest curvature is ¼ inch above the imaginary line *A-B*. When curved, this ⅜-piece is to be split into five pieces and a full-length piece is to be Ambroided in the center of the elevator frame. The other pieces are to be shortened from each end and placed 2 inches apart. Ambroid only is used for these joints, a little being applied to each contact point and allowed to dry, then a bit more applied at the juncture and the rib held there a minute or so until the adhesive sets.

When completed, this elevator frame is next bent to a dihedral angle by holding its center, first the front and then the rear, over a flame and bending it upward so that the ends are raised ¾ inch above the center. Determine this properly

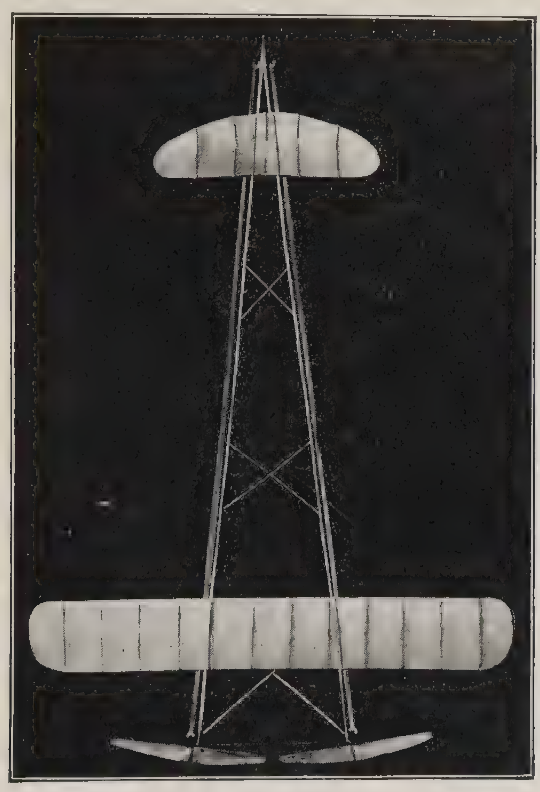


Figure 84. "P.E.G.-54" Completed

by balancing the elevator on a flat surface and noting the lift of its ends. The front edge should be bent a trifle more than the rear. Now cover the frame on the upper side only. If paper is used, apply it over the frame previously painted with dope, rub the paper to make it adhere, cut away the excess, leaving a ¼-inch margin, fold over the margin and dope it

down. If cloth is used, sew it in the same manner as that described for the metal-framed wings on the model in Chapter IX.

The propellers are to be cut on the profile with a slope from the hub to the tips, and then carved as explained in Chapter V, after which the shafts are inserted, washers put on and the shafts passed through the bearings. The 50 feet of rubber thread is to be cut in half and the ends of each half tied together to form a loop. Each loop is then to be folded in half and again in half, making two hanks of eight strands each which are to have their ends secured with little rubber bands known as "election" bands and an S-hook passed through one end. The S-hook is now hung onto the nose-hook; the other end of the hank is reeved through the cans and fastened to the shaft hook.

The main plane is fastened to the frame with two 3-inch rubber bands, passing each band under a longeron and taking the two loops on each side of the longeron and opening them up on top and passing the wing through, after which the bands will hold it in place. The elevator is similarly held in place, but in order to allow for its elevation, two inclined planes are made of a scrap of balsa wood. They are to be 3/8 inch in height at one end, tapering to 1/8 inch at the other, and 1 1/4 inches in length. These are to be fastened with Ambroid, 2 inches from the nose, and the entering edge of the elevator is to rest on them, the angle of the elevator being thus adjustable by sliding it back and forth. (See Figure 84.)

Before flying the model, glide it several times to see that it is correctly balanced, moving the wings back to correct tail heaviness and forward to hold the nose up. When ready for flight it can be wound up with about 1,000 turns on the propellers, which is 200 turns of a five-to-one geared winder, such as that described in Chapter XIII. It is launched the same way as that illustrated in Figure 81.

CHAPTER XI

THE LANGE-3, 262 4/5 SECONDS DURATION MODEL AIRPLANE

For the following description the author is indebted to the Illinois Model Aero Club of Chicago, an organization founded in 1912 which continues active to date and has numbered among its members many prominent modelmakers, quite a few of whom have made world records with their models. The Lange-3 (Figure 85) embodies modern practice in every detail and an accurate copy according to the following description will be a keen competitor in any contest. It includes the features developed by the I.M.A.C. in sixteen years of model designing, building and flying, such as the "cans," X-bracing, wire-nail bearings, shafts, elevator, A-frame, propeller and wing design, all combining to produce extreme light weight with requisite strength. The above items are distinctively this club's developments and account in the most part for its unsurpassed performances. This description was written after the specifications of Paul Schiffler-Smith and the original drawing was made by William Brock, both valuable members of the I.M.A.C. The material required is as follows:

WOOD:

Fuselage:

2 balsa longerons, 1/4 x 1/8 x 40 in.
1 piece of bamboo pole, 14 in., to be split into braces

Wing:

1 balsa entering edge, 1/4 x 1/4 x 33 in.
1 spruce spar, 1/4 x 3/64 x 34 in.

1 bamboo rear spar, 3/64 x 1/64 x 34 in.
1 piece bamboo for wing tips, 1/32 x 1/8 x 9 in., to be split in half
13 balsa ribs, 1/2 x 1/20 x 4-3/4 in.

Elevator:

1 bamboo pole, 16 in., to be split into edges and ribs

Propellers:

2 balsa, 1-1/4 x 1 x 11 in.

METAL:

2 shafts, piano wire .035
4 washers, to fit shaft
2 bearings made from 1/16 in. wire nail
6 cans, No. 10 piano wire
2 S-hooks, No. 15 piano wire
1 nose-hook, No. 15 piano wire

FABRIC:

1 sheet Japanese tissue paper, 1 x 1/2 yd.
28 ft. of 3/16-in. flat rubber thread or 40 ft. of 1/8-in. flat rubber thread
Silk thread for binding
4 3-in. thin rubber bands for holding wings
4 "election" rubber bands for use on rubber motors

LIQUID:

Ambroid for adhesive
Banana oil or dope for surfacing

Fuselage. The balsa longerons are sandpapered smooth and slightly rounded at the corners, then doped with banana oil or regular airplane dope. While they are drying, make a full-sized drawing of the fuselage, starting with a triangle 40 inches in length with a 10⅜-inch base. Using the dimensions in Figure 85, draw in the braces, then by measuring direct from the drawing you have made, the length of the braces can be obtained. Remember that they extend through the longerons and the dimension must therefore be taken between the outside edges. Next, make up all of the metal fit-

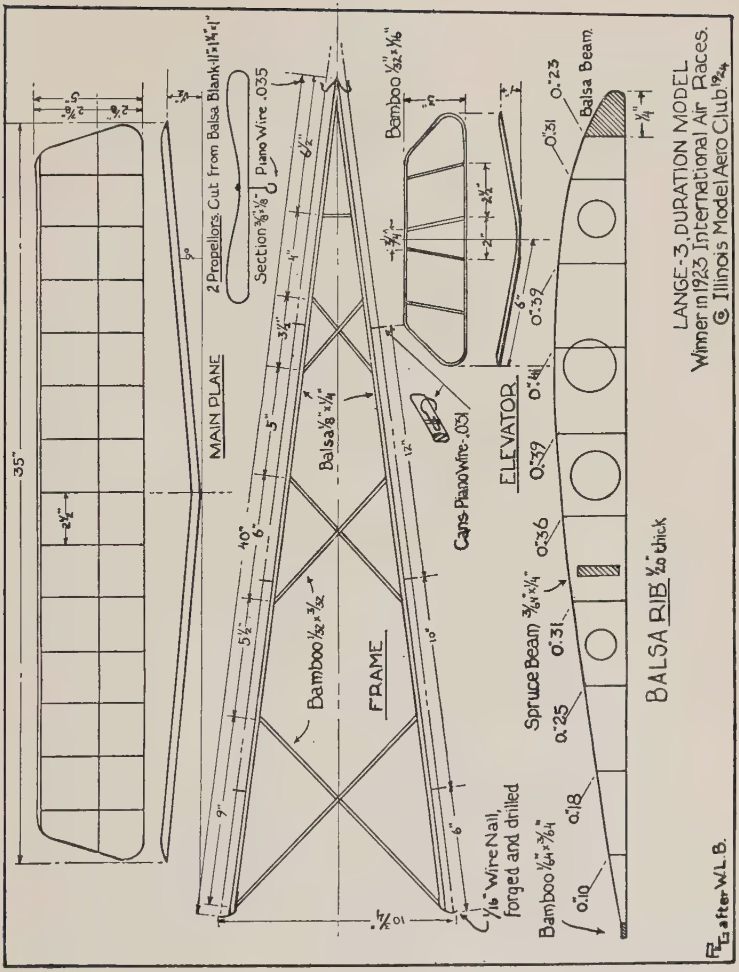

LANGE-3, DURATION MODEL
Winner in 1923 International Air Races.
© Illinois Model Aero Club. 1924
MAIN PLANE
35"
2½"
2 Propellors, Cut from Balsa Blank-11"x1¼"x1"
Section 3⁄8"x1⁄8"
Piano Wire .035
FRAME
Bamboo 1⁄32"x3⁄32"
Balsa 1⁄8"x1⁄4"
Bamboo 1⁄32"x1⁄16"
40"
10½"
1⁄16" Wire Nail, forged and drilled
Cans-Piano Wire-.031
ELEVATOR
BALSA RIB 1⁄20 thick
Spruce Beam 3⁄64"x1⁄4"
Bamboo 1⁄64"x3⁄64"
Balsa Beam
0.10
0.18
0.25
0.31
0.36
0.39
0.41
0.39
0.31
0.23
After W.L.B.

Figure 85

tings so that they can be attached as needed. Chapter VI will be helpful in this connection. Now, as has been done for the other A-frames previously described, sharpen one end of each longeron to a chisel-like edge of such inclination that when the cut faces are pinched together the opposite ends will be 10⅜ inches apart. Apply Ambroid to these faces, fit the nose-hook over the point and bind neatly and securely. Now, using a sharp-pointed knife, make slits at the points in the longerons where the braces are to go. The bamboo is split into six strips with a section of 1/32 x 3/32 inches; the strips are cut to the proper length for use as braces, the ends of the braces are sharpened and then Ambroided in their respective slits. Lay the frame over the drawing while assembling so that the resulting job will be true. To insure its trueness, sight along the sides and if they are not straight make them so by proper adjustment of the braces. Lash the centers of the cross braces. Next, bind on the nail bearings so the holes therein will be not more than 5/16 inch from the longerons. Bind on the cans; these are absolutely essential in order that the pull of the rubber motors will not bow the frame.

Wing. This is the most important part of the model and the maker can not be too careful in its construction. The rib shape shown in the drawing is copied 4¾ inches in length on a piece of paper, then this is glued to a piece of tin which is cut out and used for a pattern. The ribs can either be cut out separately by laying the tin pattern over thin slats of balsa, or a block of balsa about 2 inches in thickness can be cut with a profile like the pattern and the ribs sliced off, having a thickness of 1/20 inch. Two and seven-eighth inches from the front of the rib, a slot is made to take the spruce beam. This slot can be easily cut by chipping a big nick out of a razor blade and using the edge near the end as a cutter, as shown in

Figure 86. Holes are made in the ribs to lighten them. The wing is to have a dihedral (upward bend) of such an angle that the ends of the spar will be 1½ inches higher than the center. This angle is made in the spar by making a cut as shown in

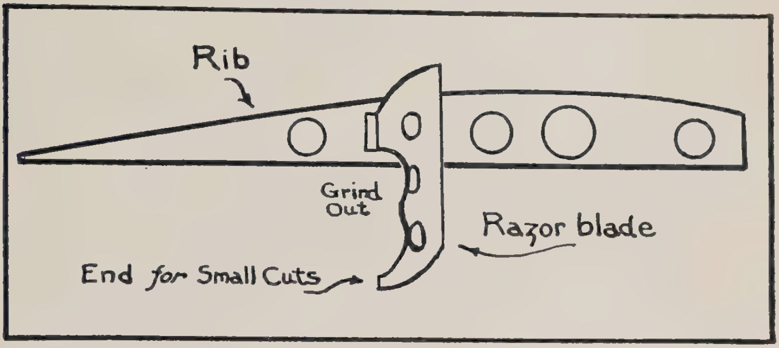


Figure 86. Cutting Spar Slot

Figure 87 and rejoining to make the angle. Lash and Ambroid this joint and when dry assemble the ribs upon the spar 2½ inches apart as shown in the drawing.

Now prepare the entering edge. Cut it in the center as in Figure 87, but before rejoining, shape each half to the section

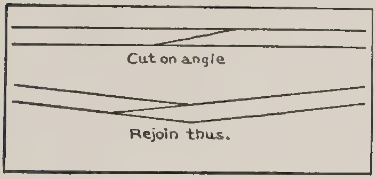


Figure 87. Spar Angle

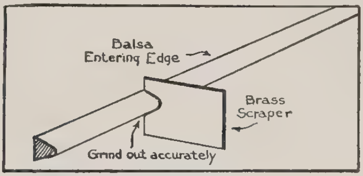


Figure 88. Finishing Wing Spar

shown in the shaded portion at the nose of the rib. Be careful to cut away the proper corners of the beam halves so that when rejoined they will properly fit the ribs. A metal template filed to the shape of the rib's nose and scraped over the beam, will insure a correct section. Figure 88 illustrates this helpful

hint. Rejoin the beam at exactly the same angle as the spar, file shallow grooves in it where the ribs touch it and Ambroid the ribs in these slots. Cutting a piece of bamboo long enough for the rear spar may present some difficulties to the uninitiated because several nodes will be encountered in splitting a piece of bamboo of this length, but if care is taken to cut straight through the nodes, and the long piece is split down to size, using a small sharp plane for the finishing cuts, the spar can be correctly formed. It is to be bent to the proper dihedral by heating the center, and Ambroided to the back of the ribs. If the frame is laid on a board and a row of pins placed down the front edge and another row along the back edge, pressing the edge against the ribs, the edge can be held in place while it dries.

Now draw, full size, the shape of the wing ends; take the 9 x 1/8 x 1/32-inches piece of bamboo, and, holding it over a candle flame, bend it to shape as the heat softens the fibers. Bend it on its side, not its edge. Lay it repeatedly over the drawing to insure correctness, and finally split it in half, forming two identical wing ends 1/16 x 1/32 inch in size. Cut steps in the wing edges and a notch in the spar to accommodate the ends and Ambroid them in place. Bear in mind to use Ambroid sparingly but effectively; in fact, this is true of all material, in order to have the essential strength with minimum weight.

The wing frame is now covered with the Japanese tissue paper, which is applied first to the bottom. After each section in turn has been painted with banana oil; the paper is laid over it and carefully adhered, then stretched tight. The top is covered in two pieces, divided at the center to avoid wrinkling; on top the paper is pulled taut, especially lengthwise, in order to prevent hollows between the ribs and to preserve the proper wing section. Be most careful at the wing tips to

avoid wrinkling. As each side is covered, after letting the adhesive dry, give it two coats of thin banana oil to shrink the surface and glaze it. Banana oil or dope can be thinned with acetone, obtainable at drug stores. Too much dope will warp the wing; too little permits the paper to sag and leaves it fuzzy.

The elevator is next made from thin bamboo. Draw the shape full size on paper, and from a piece of bamboo 1/8 x 1/32 x 16 inches, bend the shape to a trifle more than half the elevator. Then split this piece in half and join the ends with lashing and Ambroid. From a piece of bamboo 3 1/8 x 1/4 x 1/32 inches which is first bent to a shallow parabola shape, split four ribs and Ambroid them in place as shown. The frame is then covered with Japanese silk tissue paper, again using banana oil or dope as adhesive and pulling the paper taut along the upper surface. Now comes a job that must be carefully done to avoid damage. Hold the front edge over a candle flame and bend it to a "V" of such an angle that the tips are 1 inch higher than the center. The back edge should be bent to a flat-bottomed "V", bending upward from a 2-inch flat section at the center. Use the same angle as for the front edge. Exercise extreme care to get the correct shape as illustrated. This is essential as the elevator is the most sensitive part of the plane.

Propellers. Success or lack of extraordinary performance depends upon propellers. They are of Wright true pitch type. Lay diagonals on the 1 1/4-inch face and then saw to these lines allowing enough for the hub at their intersection. Drill a small true hole for the shaft, exactly in the center, then carve the propellers as opposites, one right- and one left-handed, as explained in Chapter V. Finally, round off the tips slightly and saddle in at the hub as shown. After bal-

ancing, dope them and insert the shafts, bending the protruding end over onto the hub but not indenting it. Use Ambroid in the hub, also to secure the bent part. True up the shafts, put two washers on each, and put through the bearings.

Divide the rubber into two lengths; tie the end of each length together with a square knot, loop each into 40-inch

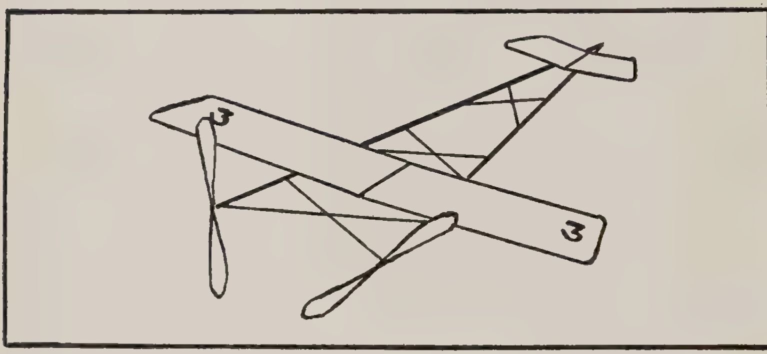


Figure 89. "Lange-3" Completed

lengths, even up the ends, put an "election" band on the ends to hold them together and insert an S-hook on each hank. Attach the S-hook onto the nose-hook, reeve the rubber through the cans and attach to the shafts. The wing and elevator are fastened to the frame with rubber bands by passing a band under the longeron, holding the two loops open above the longeron and slipping the wing underneath. The approximate position of the wings is shown in Figure 89.

The model is balanced by holding it by the propellers and launching it forward unwound. If it dives too abruptly, move the elevator forward; if it noses up and stalls, move the elevator backward. Adjust until it glides evenly, then it is ready to wind. It is capable of flights of about one mile, so select a large field for flights. Wind the propellers about 1,000 turns, preferably using a winder described in Chapter

XIII. To launch, hold it carefully by the propellers, either in front of the chest or over the head, thrust it gently forward, into the wind, and if directions have been correctly followed the model will tax your physical powers to regain it.

Models of this type have often flown out of sight of the spectators. This particular model from which the plans were drawn won first place at the Mulvihill Model Airplane Trophy Contest held at St. Louis in 1923 in connection with the National Air Races. It is customary at such times to have a motorcycle and sidecar at hand in which to ride after the model. The contestant ought to have some transportation at hand when flying his model, because a long run, with one's head up in the air watching a flight, is a severe test.

CHAPTER XII

THE WINNING MODEL OF THE 1927 TOURNAMENT

The following description is being used through the courtesy of Joseph J. Lucas of Chicago, an outstanding member of the Illinois Model Aero Club, and an expert on model building and flying. The use of three surfaces in tandem has been made famous by Mr. Lucas, for it was with a model of this type that he achieved second place in the model contest at the National Air Races held at the Sesquicentennial Exposition, Philadelphia, 1926. (See Figure 90.) At the National Playground Miniature Aircraft Tournament held in 1927 at Memphis by the Playground and Recreation Association of America, Mr. Lucas could not compete because it was limited to contestants under 21 years of age. However, he designed the model entered by his club through Jack Lefker, (see Figure 91) and by Jack it was flown for the phenomenal duration of 5 minutes and 37 seconds. Jack Lefker, who was only 12 years of age at that time, deserves much credit for the accuracy with which he carried out the design and for the skill with which he flew the model. This flight established a record for models made and flown by junior contestants. The construction of the model (Figure 92) requires the following material:

Wood:

(All balsa, except second item)

Fuselage:

2 longerons, 3/8 x 3/8 x 39-1/2 in.

1 piece bamboo pole, 10-1/2 in., to be cut into braces
1 piece balsa, 1/4 x 1/8 x 6 in., for plugs

Wing:

1 entering edge, 5/16 x 5/16 x 30 in.
1 trailing edge, 3/8 x 3/32 x 32 in.
15 ribs, 4-1/16 x 1/20 in.
2 ribs, 5 x 3/20 in.

Elevator:

1 entering edge, 7/32 x 3/16 x 10 in.
1 trailing edge, 3/16 x 1/8 x 11 in.
9 ribs, 2-11/32 x 1/20 in.
2 ribs, 3 x 1/10 in.

Tail Plane:

1 entering edge, 1/4 x 1/4 x 10 in.
1 trailing edge, 5/16 x 5/32 x 10-3/4 in.
9 ribs, 2-3/16 x 1/20 in.

Propellers:

2, 12-in. diameter, cut as explained in text

Metal Fittings:

(To be formed of .035 in. piano wire)
2 shafts
2 bearings, as per drawing
6 cans as per drawing
2 S-hooks
1 nose-hook
6 washers

Fabric:

1 sheet Japanese tissue paper, 1 x 1/2 yd.
1 spool silk for binding
26-1/2 ft. of 3/16-in. flat rubber thread
3 3-in. rubber bands for attaching planes
4 election rubber bands

Liquid:

Ambroid for adhesive
Dope or banana oil for treating surfaces

Proceed with the construction by starting with the A-frame motor base which has the tail plane inserted in the rear. The longerons are to be made into "I" section as shown in Figure 92, having 1/16-inch flanges and ⅛-inch web. The "I" sec-

Figure 90. Joseph J. Lucas of the Illinois Model Aero Club—A Pioneer Model Builder and Flyer

tion can be made with a penknife and small chisel, or if the constructor has access to a circular saw the work can be done more easily and accurately by proper adjustment of the saw-table and guide. The longerons are sandpapered smooth and painted with dope to strengthen them, then one end of each is cut to a chisel-like taper, so that when the tapered ends are placed together, the other ends will be 11 inches apart. The nose is then Ambroided together, fitted with the nose-hook and bound neatly. The bamboo piece is next split so that four

pieces $\frac{1}{8}$ x 1/32 inches in section are obtained. From these, the two X-braces are made and inserted at the places indicated by the drawing. They are attached by the method shown at the detail named "Frame Joint Section" by using the

Figure 91. Jack Lefker and His Record Breaking Model

short piece of balsa $\frac{1}{4}$ x $\frac{1}{8}$ inches in section and cutting it into little plugs about $\frac{3}{8}$ inch in length which are Ambroided in place and into which the bamboo braces are fastened by sharpening their ends to a chisel-like point and Ambroiding them in slits made in the plugs. The braces are pushed well into the plugs to secure a firm joint. A small straight bamboo brace is attached in the same manner 6 inches from the nose. Before the Ambroid sets, sight along the longerons, making sure that they are straight; if not, move the braces to make them so, being careful to preserve the proper separation at the rear.

The next part of the frame to make is the tail plane. The entering and trailing edges are cut to the section shown

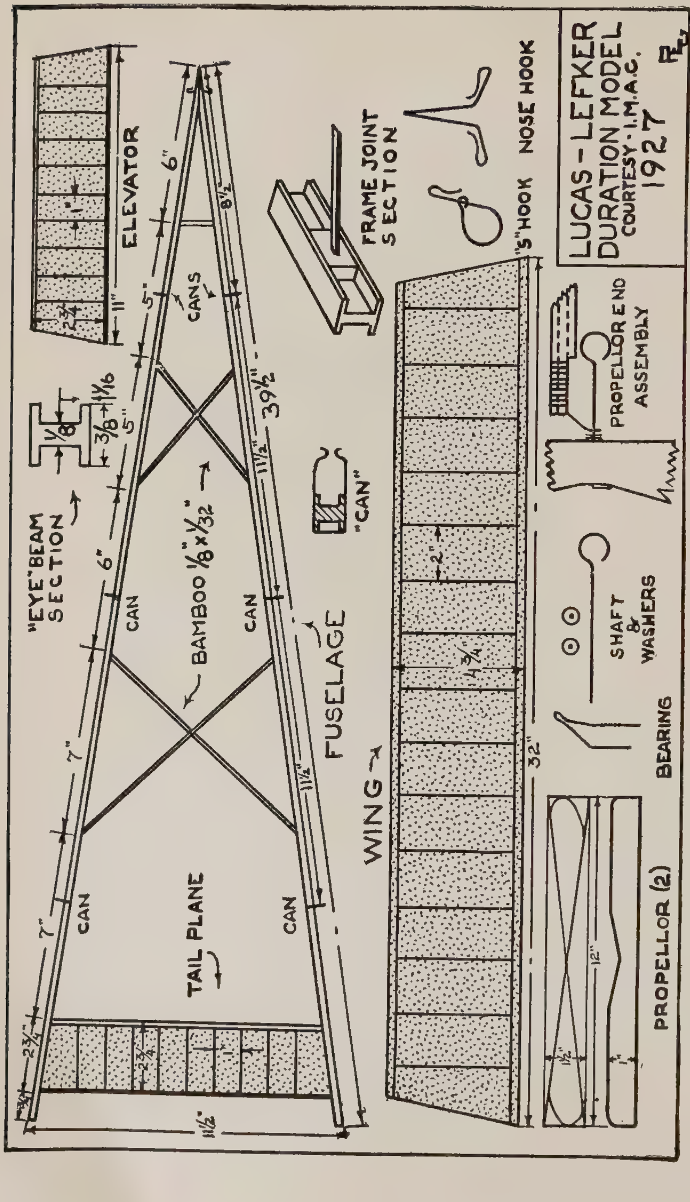


Figure 92. Winner of the First National Playground Miniature Aircraft Tournament

in Figure 93. This may be done with a small plane, penknife, or by cutting a metal scraper with a slot of the proper section and using it to reduce the sticks to the right shape as shown in the drawing. The ribs may be made in one of two ways. A block may be cut having a profile like the drawing and about 1½ inches in thickness; this block may be sliced into ribs, or the pattern may be transferred to a piece of tin which is cut out to that shape and used as a template, then laid on thin slats of balsa, and used to cut around with a knife. A circular saw is of course the best tool for slicing the ribs or slats, but because balsa wood is so soft, a thin knife will do nearly as well. The edges and ribs are now painted with dope to strengthen them. Small slots are cut in the entering edge, one inch apart, and into them the ribs are Ambroided. The trailing edge is Ambroided direct to the ribs without having been slotted. If the tail frame is laid on a board and pins are placed in the board against the edges, the frame can be held while the Ambroid sets.

The tail plane is attached to the A-frame by placing little balsa plugs in between the flanges of the longerons, Ambroiding them in place and cutting little recesses in them to receive the tail-plane edges, which are Ambroided therein. Figure 92 shows the position of these plugs. The cans are now formed to the shape shown in the detail drawing and Ambroided in their respective places. The bearings are bent from piano wire and attached to the rear of the frame with thread and Ambroid. The tail plane is covered with tissue paper. To do this, paint each edge on the under side with dope, lay a piece of tissue thereon, and lightly rub over it to make it adhere. See that it is smooth and tight. Lift the fabric where it lays over the longerons, paint dope under it, and rub that down. When dry, trim away excess paper. Similarly, cover the top, trimming the paper on the edges

with a slight margin which is folded around and doped to the under edge. When dry, paint the entire surface with banana oil or dope thinned with acetone. This completes the A-frame.

The main plane is a very important part of the model and must be made with great care to insure successful flights. The

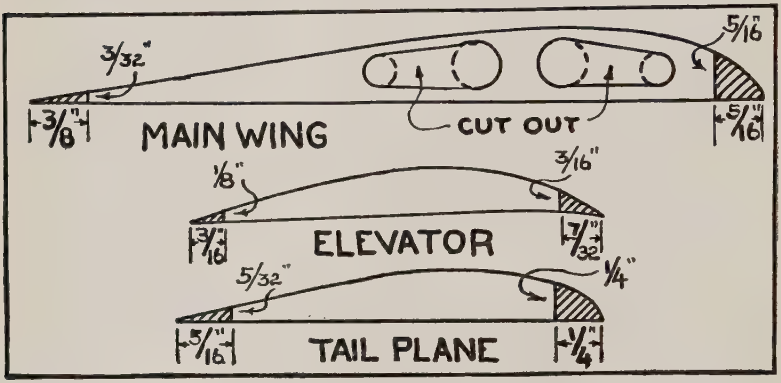


Figure 93. Rib Sections for Lucas-Lefker Model. Lengths of ribs between shaded portions are 4-1/16, 2-11/32 and 2-3/16 inches.

balsa edges are cut to size, sandpapered smooth and doped, then cut in half and rejoined at a slight dihedral angle. The angle should be such that when one side is laid flat and horizontal the other end will be 2 inches above the surface. The edges are rejoined by bending a short piece of small section bamboo at a slight angle, then Ambroiding and binding it to the abutting pieces which are also coated with Ambroid. Next, as with the tail plane, the entering edge is slotted, and the ribs, cut to pattern in Figure 93 and doped, are Ambroided in place, 2 inches apart. In order to lighten the ribs, small cut-outs are made in their centers as shown. If the metal end of a pencil has its eraser pulled out and its edges sharpened, it can then cut out little circles of balsa from the rib, in the same manner as a cook cuts dough into biscuits; the circles can be joined with knife cuts to produce the cut-outs illus-

trated. The trailing edge of the wing is attached as was that of the tail plane. The wing tips have approximately the same section as shown (Figure 93) but are slightly longer as they are to be attached at a slant. The ends of the wing edges are cut at a bevel and the wing-end ribs are Ambroided thereon.

(Courtesy: Joseph Lucas)

Figure 94. Jack Lefker Launching His Model

The wing is covered as was the tail plane; the bottom being covered and doped first, then the top being covered in two pieces, one to each half of the angle. This is necessary to prevent wrinkles at the center. When dry the top is doped with a thin solution.

So much has been learned about wing construction by making the two preceding surfaces that the elevator will re-

quire no special instructions, other than to point out that the dihedral angle is greater, each side being raised 1½ inches from the horizontal.

The propellers are carved from blanks 12 x 1½ inches and 1 inch in thickness. The plan view of the blanks resembles the Langley pattern illustrated in Chapter V, which is easily cut out by drawing diagonals on the blank and sawing along them to the center, leaving there, however, a small hub. The hubs are accurately bored for the shafts with a No. 65 drill; then as shown in the side view of the model, the hubs are cut in to lighten them. Then the propellers are carved, one right-handed, one left-handed, as explained in Chapter V, after which their ends are rounded off and the propellers are balanced and doped. The shafts are inserted and their projecting ends bent over and Ambroided to the hub. Use Ambroid on the shaft before insertion to insure good adhesion. See that the props run true on the shafts without wabbling. These propellers are of the Wright true-pitch type having a pitch of about 25 inches. Put three washers on each shaft and insert the shafts through the bearings. Divide the rubber into two lengths; from each make a four-strand hank, secure the ends with election bands, attach S-hooks and put the rubbers on the model as has been done for previous types.

The model is now completed, but before flying, glide it several times to establish the balance and the correct placement of the surfaces. The model is a very consistently good flyer and for its proper performance a large field will be required. At the Memphis Tournament, when the model flew over 5½ minutes, it traveled more than one mile. (See Figure 94.)

CHAPTER XIII

MODEL FLYING ACCESSORIES

The addition of a few easily made accessories greatly increases the pleasure of model flying by reducing the tedious work and leaving more time for actual flying.

The most useful accessory is a winder for twisting the rubber bands which form the power plant of the model. If the modelmaker has, among his tools, a geared hand-drill, this will serve well as a winder by putting a hook into its chuck and attaching the rubber strands to it. However, in the case of a twin-motored model, this winds only one strand at a time, and for the second strand it is necessary to revolve the drill backward in order to have the propellers run in opposite directions. A winder which will twist both strands at once, and in opposite directions, may be made from an egg-beater in the following manner.

Select an egg-beater which is strongly made and has the shafts firmly imbedded in the frame. Figure 95 illustrates a typical example. At the top is an egg-beater as it comes from the store. Cut off the whirling blades and shafts where indicated by the dotted line, using a hack-saw or file. The gears with the attached strips can then be pulled off. By reference to the left of the drawing we see at *1* that one side is cut off shorter than the other, and where the lines indicate, holes are bored through the strips large enough to pass snugly over the shaft. Bend these ends over as at *2,* so the holes are in line. Some makers may find it easier to bend the sides first and drill through both at once. By either method bend and drill

each side. Next make two wire fittings as shown at *2-A* (Figure 95). Now put each of the gears back on the shafts as shown at *3*, and solder washers, which have a hole just large enough to pass over the shaft, to the end as shown. If neces-

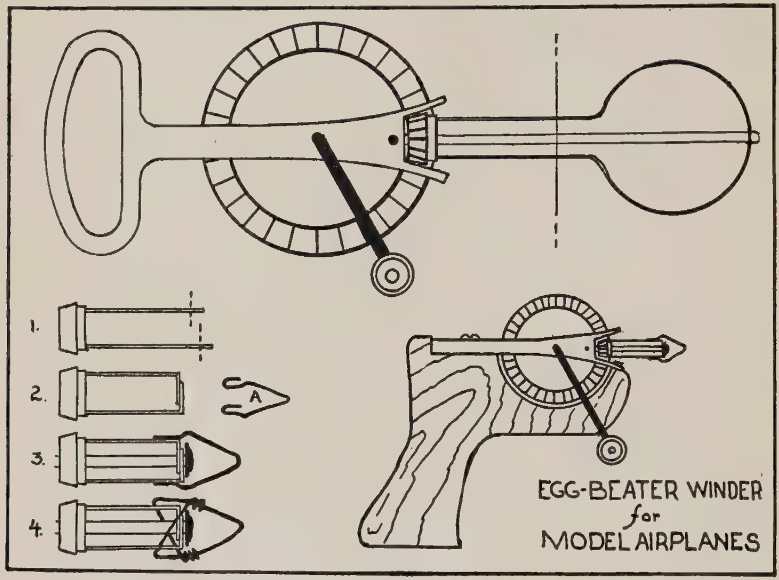


Figure 95

sary cut off the shaft so the washer will make a snug fit with just enough play to permit free running. Solder the wire fitting to the sides. This completes the winder, but in the event that the metal side strips are made of aluminum as is often the case (which makes soldering difficult) an equally satisfactory job can be done by riveting the washer to the shaft and making the fitting by twisting the wire through holes as at *4*. Many prefer to leave the original handle on the winder but others desire a more comfortable handle, as by sawing a pistol grip out of wood and attaching the winder to it with screws. These directions may be slightly altered if the original egg-beater is of a different pattern.

The effort required to make one of these winders is more than repaid by the ease with which the model may be wound. Most egg-beaters have a gear ratio of one-to-five, therefore a twin-pusher model with one of these devices may be wound in one-tenth of the time required by hand. Keep well oiled when in use. The winder is shown in Figure 180, where the S-hooks on the rubber strands are shown as unhooked from the model and attached to the wire fitting. When operating the winder, use care in turning so that the propellers will revolve properly. If they do not, it will be easier to correct the direction of winding by turning the model upside down than by operating the winder backwards. Before winding, stretch the rubber about three times its normal length and as you wind (see Figure 180) approach the model so as to arrive with the winder at the model when the strands are fully twisted. Unhook from the winder and attach to the model; in case of a twin-pusher, guard the fuselage against breakage as the strands are hooked on. If the rubbers are wound up, then allowed to run down, then wound up again, they will take more turns the second time. This is a helpful hint for duration flights.

A Model-Carrying Box

Because model aircraft are made light in order to fly well, they are usually quite fragile and care must be taken to guard them against injury. A model-carrying box is useful for this purpose and serves to preserve the parts, while the model is under construction, also to carry the finished models to and from the flying field. Figure 96 shows a type that will accommodate models up to 42 inches in length; of course the dimensions can be increased for larger models. The following material is necessary:

1 board of white pine (or poplar, etc.), 9 ft. x 6 in. x ½ in.

1 piece of compo board (or beaver board, etc.), 44 x 21 in.
2 butt hinges, 1½ x ½ in.
2 fasteners
1 handle
Screws, nails, paint

First cut the 6-inch board into four pieces, of which two are 42 inches in length, one 14 inches, and one 7 inches. Plane

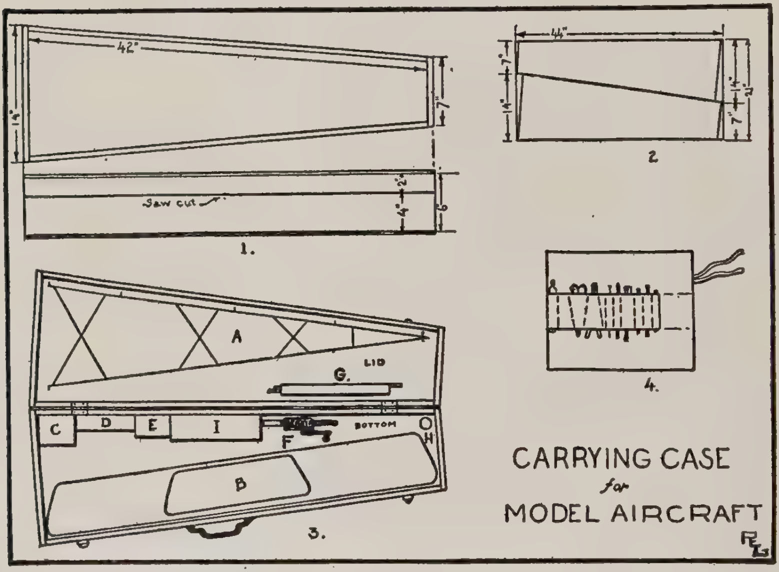


Figure 96

the ends of the long pieces to a slight angle as shown in Figure 96-*1*, so as to make a snug fit at the corners. Glue and nail the frame together using eight-penny finishing nails. Next cut the compo board as shown at *2* and nail these sides to the frame. Use flat-head nails, preferably No. 14, 1 inch. Make a mark 2 inches from one side, all around the box and saw the box apart on this line. Plane the sawed edges, hold the box

together again and mark the positions for the hinges (6 inches from each end). Now open the box and with a chisel cut little depressions to take the hinges, then screw in place as shown at *3*. The depressions must be deep enough to permit

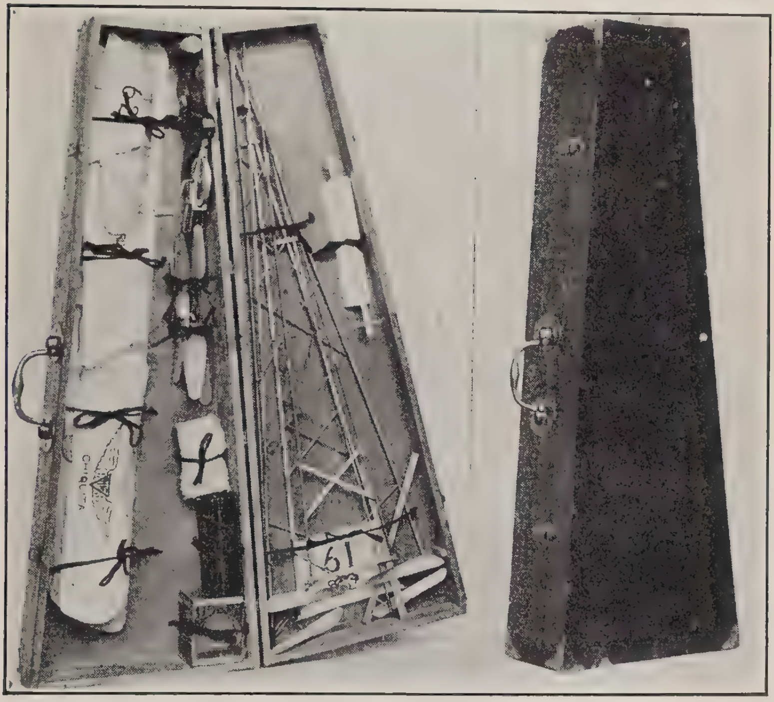


Figure 97. The Model Box Open and Closed

the edges to fit snugly when closed. The fasteners may be regular valise catches, hooks, or even window fasteners. These are attached so as to hold the box together when closed. You can now paint the box, preferably black outside, and shellac or paint inside, after which provision may be made for fastening the model parts inside.

Figure 96-*3* shows an arrangement of parts where *A* is a fuselage; *B* the wings; *C* a can of rubber strands; *D* a box

containing Ambroid, spare parts, dope, etc.; *E* a tool-roll such as that shown at *4; F* a winder; *G* a roll of scrap wood and fabric for patches; *H* a spool of thread; and *I* a box of propellers. These various objects may be held in place by tapes attached to screw-eyes or the various items may be in boxes built into the carrying box itself. When it is loaded, find the balancing point and there attach the handle which may be a piece of leather strap held by screws or bolts, or a drawer handle. The Model Club insignia or owners' name should be painted on the outside; the addition of brass or nickel corners makes the box more attractive and durable. Figure 97 shows such a model box open and closed.

Winding Hooks

Although tractor models can be wound by holding the model in one hand and rotating the propeller with the other, they may be more efficiently wound when the rubber is

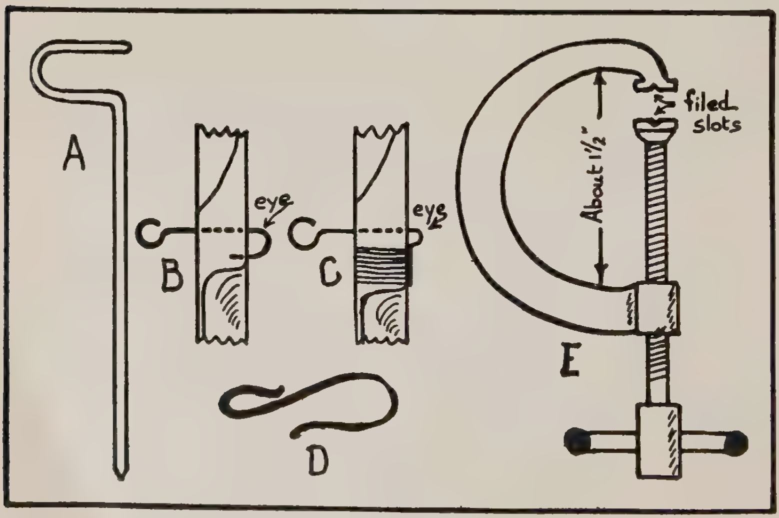


Figure 98. The Use of Winding Hooks

stretched out with the aid of an assistant and a geared winder. For a twin-propeller ship such aid is nearly indispensable. There may be times when one would want to fly models but could not get his chum to accompany him, or he might be in

Figure 99. Carl Fastje Using a Winding Jig

company of other boys who may be so engaged that they could not help in the wind-up. At such a time a winding jig becomes a valuable accessory. Winding hooks are made of iron rod about 1/8 inch diameter and 1 foot in length with the end bent as in Figure 98-*A*. These take the place of an assistant for holding the model if your propellers are properly arranged. To fit your model for using winding hooks, *B* and *C* show how the projecting end of the prop shaft, in the case of pine propellers, is bent over back into the wood leaving a loop, and in the event of balsa wood, bent with a slight hump before being flattened out upon the hub and bound. An S-hook of heavy construction (about 1/16-inch wire) is hooked onto these propeller loops and the other loop is hung over the winding hooks which are pushed into the ground as far apart as the shafts are distant. Push them in at an angle so they will better resist the pull when in use.

Chapter V explained how and why the propellers on a twin-pusher should be placed to get best results, that is, to revolve upward and outward from the center. Chapter XIII recommended that a geared winder with the driving gear between the pinion gears be preferred. If these two suggestions have been followed the reader has learned that he must hold the models upside down when winding in order that the winder will turn the propellers correctly. Therefore, to use winding hooks, lay the model on its back on the ground, push the winding hooks into the ground in back of the propellers. With the S-hooks just made, join the propeller eyes and the winding hooks, then the model can be wound from the nose end as usual and because the model is upside down the rubbers will not be interfered with. The hooks should go into the ground at a slant in order to get the best resistance against the rubber pull.

If the winder has an outside gear or if for any other reason the model can not rest on its back, the winding hooks can be used just the same and the nose elevated by a stick so the rubbers will be clear.

Should the reader desire to use winding hooks with propellers that have not been made with eye-shafts, C-clamps shown at *E* can be hooked over the propeller and clamped onto the shafts just back of the rubbers. The filed slots in the clamp are made to insure a better grip on the shaft. The bend of the clamp now goes on the winding hooks. With these suggestions the reader can easily devise other methods for holding the models when he is making "solo flights."

Measuring Devices

A stop-watch is very handy for timing the duration of flights. An ordinary watch will suffice if close attention is paid to the second hand.

The measurement of distance which a model flies is a more difficult problem. There is no way available to the average model flyer for measuring all the turns a model may make in

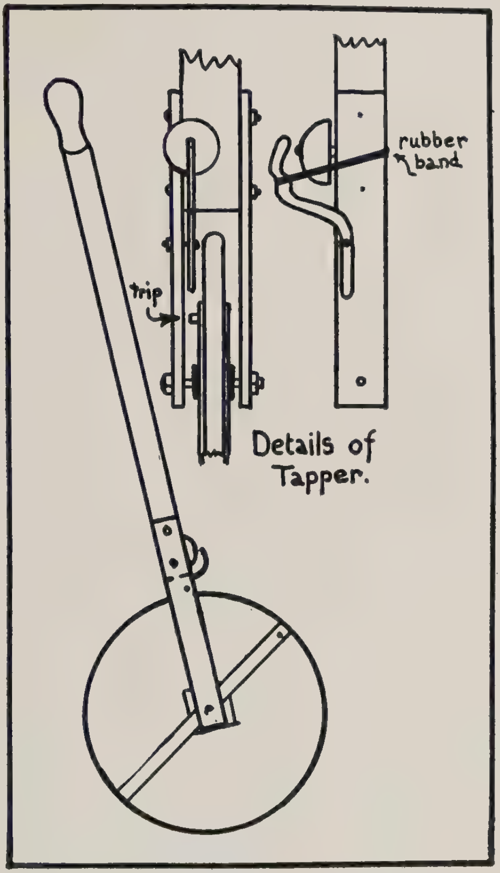


Figure 100. An Odometer or Measuring Device

flight; therefore distances are usually measured in a straight line from start to finish. Many measurers use a fifty- or hundred-foot tape, but in the case of a half-mile or longer flight, such a method becomes tiresome. An odometer is much handier. It consists of a wheel having a circumference of any

convenient unit, with a tapper or counter mounted on it to register the revolutions. Figure 100 shows a good type. The wheel is 1 yard in circumference, slightly less than 11½ inches in diameter. It is made of hard wood with a 2-inch square cut out of its center and braced across the grain with an iron strap. These straps are drilled with a ¼-inch hole at the center, these holes being the bearings. It is held by two side-pieces forming a fork which in turn is fastened to the handle. On the iron brace is a projection which, in revolving, trips a tapper. The odometer is rolled along the ground from the starting point to the place where the model has landed, the one using it counting each revolution. The number of revolutions equals the number of yards, or multiplied by three, the number of feet covered. Figure 83 shows an odometer with a 2-foot circumference and in the left corner of the case (Figure 190) is shown the one just described. If a counter is used instead of the tapper, the need for counting each revolution becomes unnecessary.

A First Aid (to Models) Kit

If the reader plans to do very much model flying, or if he is a member of a club that wishes a very handy accessory, he will find that a repair kit such as shown in Figure 101 is very handy. The one illustrated is the property of the Capitol Model Aero Club of Washington, D. C., and is a great help at their model contests. To the lid is attached a piece of cloth with stitched pockets for various devices. The three pockets at the top contain a box of razor blades, an oil-can and a stop-watch. The lower pockets contain an assortment of pliers and cutters, scissors, pencil, drill, drill-box, tweezers and ruler. The two large drawers are for wood and fabric. The small drawers contain shafts, hooks, cans, washers, wing clips, rubber bands and tubes, bearings, and in the lower one, a candle for bam-

boo bending, matches, wire, etc. The next partitions contain piano wire and thread. To the right are cans containing Am-

Figure 101. A First Aid (to Models) Kit

broid, dope, banana oil and talcum powder (for dusting the rubbers to prevent sticking). A little dish for receiving

dope is also shown. A reel at the extreme right contains rubber for the motors, and below it is a partition for sandpaper. The drawers above, besides wood and fabric, hold small tools, brushes, etc.

Not only is such a kit handy in the field, but at home it serves as a place to keep one's model-making things together. The outside dimensions of this particular kit are: length 19 inches, width 12 inches, depth 6 inches.

A Guard Rope

Frequently at model-flying contests, the spectators are so interested in what is going on up in the air that they neglect to

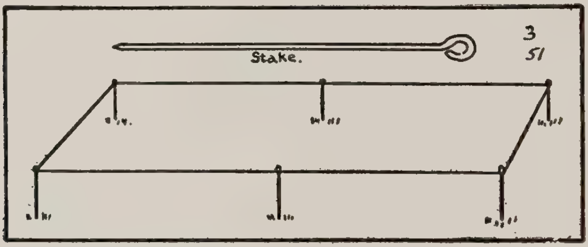


Figure 102. Iron Stakes for Guard Ropes

notice what their feet are doing on the ground. Often this results in broken models. A wise precaution is the stretching of a guard rope around an enclosure in which the model-makers may assemble and repair their models without risk. Some clubs carry a guard rope with them and support it on six iron stakes with eyes at the top as shown in Figure 102. These stakes may be easily made by the local blacksmith; they are well worth the original small cost and the slight trouble of carrying them because of the models they protect.

Markers

At a contest, where speed is desired in conducting the meet snappily, it is well for each flyer to have a small flag

marked with his number or device which he can push into the ground at the point where his model lands so that he can return to the starting point in readiness for the next flight; meanwhile the distance-measurer proceeds with measuring until he reaches the flag which is then retrieved and returned to its owner.

All of the above devices will prove to be useful and perhaps may suggest others to the reader.

CHAPTER XIV

TRACTOR MODELS FOR FLYING OUTDOORS

The tractor type of model is not seen as often as the twin-pusher type because it is more difficult to balance and requires more patience to fly. However, when properly adjusted, tractors are very good flyers; their appearance is nearer that of the man-carrying originals, and because they are usually made with only one propeller, they are lighter, require less material and are easier to build than twin pushers. Tractors with two propellers are often built and fly well. The writer recalls a twin tractor that was surprisingly fast, flying at more than 40 miles an hour.

Figure 103 shows an excellent tractor. It will be noticed that the wing is set farther back than is the case with man-carrying tractors; this is because the wing must be placed where the most weight is carried. In the case of a man-carrying machine the engine, tanks, pilot, etc., are up front, therefore the main wing is placed there also, but in a model the power is strung along the length of the frame and the wing is put about where this weight balances. This model has a divided frame, thus giving good support to the wing. The rudder is large enough to overcome the twisting force due to the use of only one propeller; in twin-propellered models the twists of the opposite turning propellers counteract each other.

Tractor Type

To construct the model shown in Figure 103, the material

enumerated below is required. Balsa wood should be used if obtainable; if not, white pine or a similar light wood will do.

WOOD:

Fuselage:

2 longerons, 30 x 1/4 x 1/16 in.
1 bamboo pole, 14 in.

Wing:

2 edges, 24 x 1/8 x 1/16 in.

Elevator:

Bamboo

Rudder:

1 base piece, 1/8 x 1/16 x 6 in.
Bamboo

Propeller:

9 in. diameter, 7/8 in. wide, 3/4 in. thick

Motor Stick:

1/4 x 3/16 x 29-1/2 in.

METAL:

4 ft. of No. 16 aluminum wire for ribs
1 nail bearing
1 shaft (No. 15 piano wire)
2 cans (No. 10 piano wire)
1 S-hook (No. 15 piano wire)
1 tail-hook (No. 15 piano wire)
2 rudder clips (No. 10 piano wire) as per drawing
2 washers

FABRIC:

1 sheet Japanese tissue paper for covering
Thread for binding
15 ft. rubber thread, 1/8 in. flat

LIQUID:

Ambroid and dope

Construction of Fuselage and Empennage. We will begin by sandpapering the longerons smooth and slightly beveling

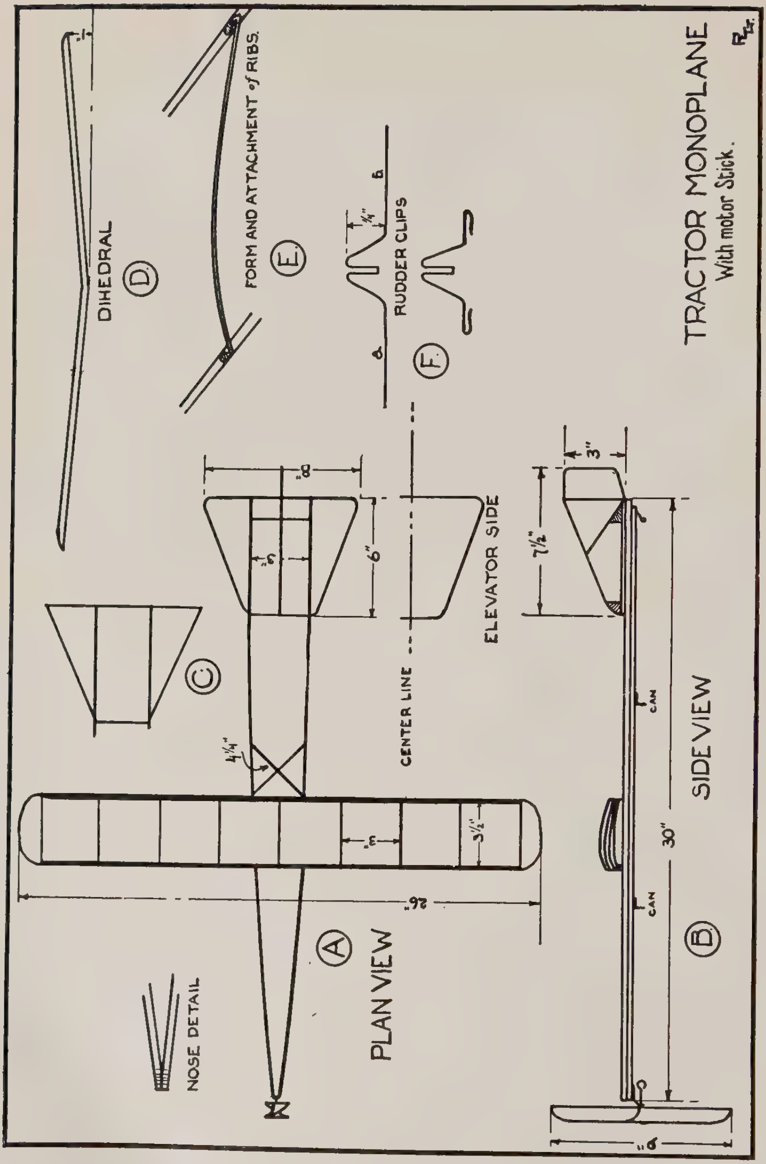

TRACTOR MONOPLANE
With motor Stick.
PLAN VIEW
A
SIDE VIEW
B
C
DIHEDRAL
D
FORM AND ATTACHMENT of RIBS.
E
RUDDER CLIPS
F
ELEVATOR SIDE
CENTER LINE
NOSE DETAIL
26"
30"
CAN
CAN
3"
3½"
4¼"
6"
8"
3"
7½"
3"
9"
¼"

Figure 103

one end of each as shown in *A,* "Nose Detail," and lashing these ends together with Ambroid between. Next, split from the bamboo pole two strips, 3/32 x 1/32 inch. Cut off one piece 3¼ inches, and two pieces 4¼ inches. Sharpen the ends of each to a chisel-like edge. With the point of your penknife make a slit in the inside edge of the longerons, 1 inch from the rear end, and also 12¼ inches and 15 inches from the end. Into the rear set of slits insert and Ambroid the 3¼-inch bamboo piece. From the 4¼-inch pieces make an X-brace and similarly fasten it in the other slits.

It should always be the desire of the modelmaker to have his models pleasing in appearance as well as in performance; therefore it is suggested that the empennage be made from bent bamboo as shown, although if this proves difficult a more simple form made of straight pieces of bamboo is shown at *C*. Assuming that the bent form is to be made, split a piece of bamboo ⅛ x 1/16 x 14 inches, and holding it over a flame bend to the shape shown by the sketch, "Elevator Side." Carefully split it in half, forming two 1/16-inch square pieces; lash these in place, using Ambroid as adhesive and overlapping the ends a little.

The rudder is made as a separate piece, taking the base piece, Ambroiding and lashing to it a piece of 1/16-inch square bamboo which is 12 inches in length and bent to the shape shown. When bending bamboo it is always best to draw a full-sized diagram of the piece to be formed and frequently compare the wood with it while the bending is being done. Two braces are used, one upright and one diagonal. These are Ambroided in place. In the two lower corners, thin slats of wood 1/16 inch thick are Ambroided. Now cover the elevator and rudder on one side, first coating each frame with dope and applying the paper, stretching it tightly in place, leaving no wrinkles; trim along the edges with a slight margin, then bend

this margin over the edges and dope down. When dry, give the surface a painting of dilute dope to tighten the fabric. Have the dope well diluted with acetone or its pulling force when drying will warp the surfaces.

From No. 10 piano wire form two rudder clips as shown, the upper one being made from a piece 2½ inches and the lower

Figure 104. Tractor Flown by Warren DeLancey at Philadelphia International Model Contest, 1926

one an inch shorter. The central space should be 1/16 inch in width, to grip the bottom of the rudder. The longer one is lashed to the center rear of the elevator, being fastened at two points, *a* and *b* only. The other clip is lashed to the center front of the elevator and is securely fastened, the two bent back ends being designed to keep it upright. Then if the rubber is set in these clips it will be held securely; and by moving the rear clip from side to side the rudder can be moved for making the model turn.

Wing. The two edges are sandpapered smooth and bent to a slight angle from the center by holding above a flame and bending it as the heat loosens the wood fibers. The proper curve or dihedral is shown at *D*. The ribs are formed from the aluminum wire, cutting 9 lengths 3¾ inches, bending over each end ⅛ inch and forming each length into a curve as shown at *E*, after which the bent ends are flattened so they can be lashed to the edges. When these have been installed, curve the wing ends from two 6-inch lengths of wire and lash in place, using Ambroid of course. The wing frame is next covered on the upper side with paper. To prevent wrinkles, cover it in two halves from the center, applying dope to each frame in turn and pulling the fabric taut lengthwise rather than across in order to preserve the section. Trim with a slight margin and dope this margin over the edges. Give the wing a coat of dilute dope when dry.

Power Plant. This model uses a motor stick whose rear end is free so the twisting due to the rubber torsion will not distort the model and make it fly untrue. The motor stick made to the dimensions given in the material list is sandpapered true and to it are lashed, with Ambroid as adhesive, the bearing, cans, and tail-hook. The front end is now lashed securely to the nose of the fuselage; the rear end is fastened loosely to the rear cross brace with a small rubber band. The propeller is carved by the method given in Chapter V and the shaft is attached with its hook on the concave side. Washers are used to reduce friction and the shaft is passed through the bearing. The rubber is made up into a hank of six strands and attached to the shaft in front, reeved through the cans and hooked to the tail with the S-hook.

Assembly and Flying. The rudder is clipped in place. The

wing is fastened about in the position shown, using a rubber band passed under the frame and over each side of the wing. A 3 x ⅛-inch square stick is placed under the front edge. The

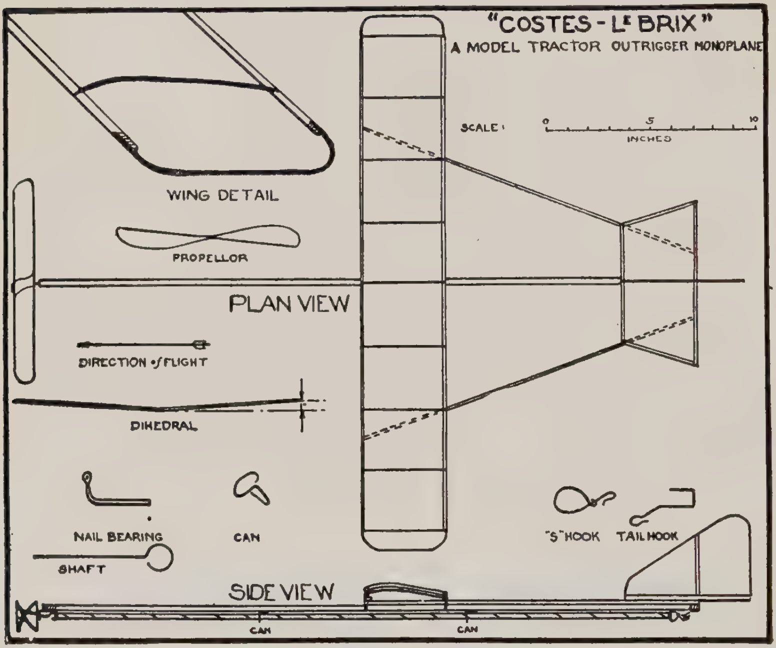


Figure 105

balance of the model is ascertained by launching it gently forward. If it rises and stalls, falling on its tail, move the wing slightly backward. If it noses down too abruptly, move the wing slightly forward. When the model makes an even glide it is ready to fly. The rubbers should be wound about 250 turns of a five-to-one winder, as described in Chapter XIII. Select a large open field for flights. In launching a tractor, it is not pointed upward like a pusher, but is cast forward at an imaginary spot on the ground about 200 feet away.

Figure 105 presents a different type of tractor construction

in which the tail is rigidly fastened to the wing with outriggers and the motor stick is fastened also to the wing but connected loosely to the tail and left free in front. This type was constructed very successfully by Walter and Gardner Dean of

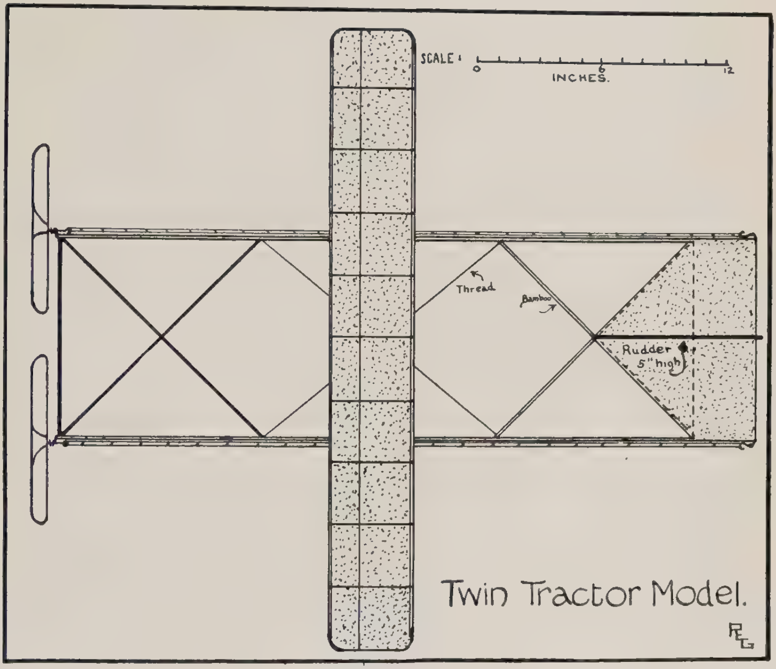


Figure 106

Chevy Chase, Md., and by them flown repeatedly. Adjust for balance by sliding the motor stick in or out.

Figure 106 shows a twin tractor in which the motor sticks form the two parallel sides of the fuselage with the empennage attached to their rear and the wing fastened by rubber bands so that it can be adjusted for best flights. In Figures 105 and 106 dimensions are indicated, but no detailed directions are given here as their construction is obvious to a reader who has made other models from this book.

Tractor Monoplane

Figure 107 illustrates a tractor monoplane which is similar to those that have established world records for performance. It requires the following material:

WOOD:

Fuselage:

1 longeron, balsa, 46-1/2 x 3/4 x 3/16 in.

Empennage:

1 stabilizer outline, bamboo, 30 x 1/16 in. square
1 stabilizer cross-brace, bamboo, 9 x 1/16 in. square
1 rudder outline, bamboo, 19 x 1/16 in. square
1 rudder brace, balsa, 4 x 1/8 x 1/16 in.
1 rudder brace, balsa, 2 x 1/8 x 1/16 in.
2 rudder braces, balsa, 3 x 1/8 x 1/16 in.

Wing:

1 spar, spruce, 40 x 3/16 x 1/16 in.
2 edges, balsa, 36 x 1/8 x 1/16 in.
1 wing end piece, bamboo, 9 x 1/8 x 1/16 in.
19 balsa ribs, 5 x 1/2 x 1/16 in.

Propeller:

11 x 1 x 1 in.

METAL:

1 nail propeller bearing
1 shaft, and 2 washers
3 cans
1 tail-hook
1 S-hook
2 wing clips

FABRIC:

2 sheets Japanese silk tissue paper
24 ft. of rubber thread, 1/8 x 1/32 in.
2 election rubber bands
Thread for binding, Silk-A

LIQUID:

Ambroid and dope

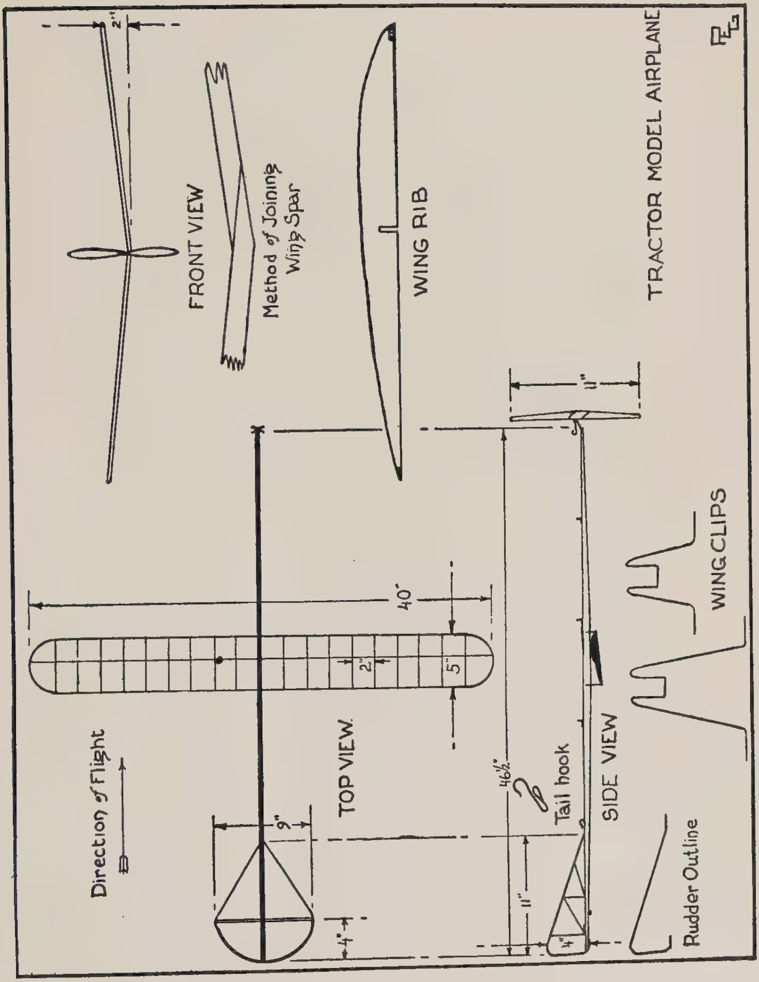
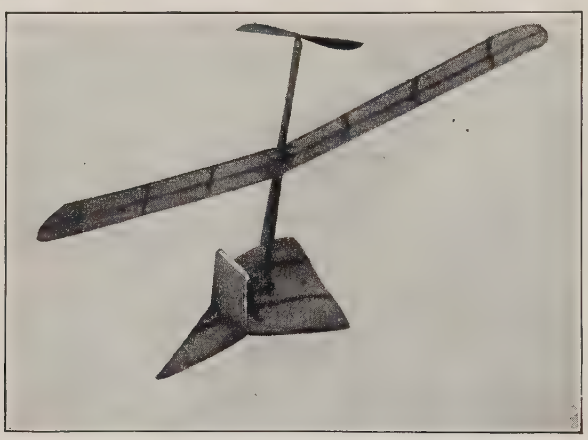

FRONT VIEW
Method of Joining Wing Spar
WING RIB
TRACTOR MODEL AIRPLANE
Direction of Flight
TOP VIEW
40"
2"
5"
9"
4"
46½"
11"
Tail hook
SIDE VIEW
WING CLIPS
Rudder Outline

Figure 107

Construction of Fuselage and Empennage. The motor stick is tapered from ¾ inch width in the center to 3/16 inch square at the ends, after which it is smoothed with sandpaper and given a coat of dope to strengthen it. The rudder outline is



(Courtesy: Bob Sommers)

Figure 108. Lathrop Tractor with R.A.F.-15 Wing. Duration, 427 sec.; Distance, 5,110 feet

bent from the bamboo intended for that purpose, to the shape shown which is drawn full size on paper and used as a pattern while bending. Lash and Ambroid the rudder outline to one end of the stick and Ambroid in the rudder braces with their flat dimension longitudinal. The stabilizer brace is fastened in place on the under side of the motor stick 4 inches from the end. Bend the stabilizer outline to shape and fasten in place. These two surfaces are now covered on one side with Japanese silk tissue paper. This is done by first painting the frame with dope as an adhesive and then laying the paper in place and stretching it taut. When dry, trim with a slight margin and dope the margin over the edges. Next, lash in their proper places the nail-bearing, three cans and tail-hook. The propeller

is carved from the blank by the method advocated in Chapter V, after which the shaft is inserted, strung with the washers and passed through the bearing. The rubber thread is looped into a hank of eight strands, fastened at each end with an

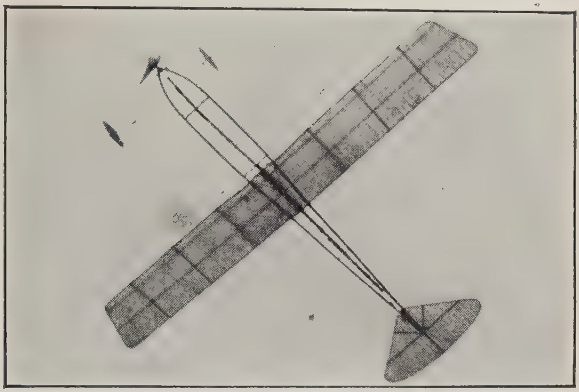


Figure 109. An R. O. G. Tractor Designed and Made by Carl H. Fastje, Denison, Iowa

election band and attached to the shaft, reeved through the cans and hung to the tail-hook with the S-hook.

Wing. The spar is cut in the center and rejoined at an angle as indicated in the detail drawing. The two balsa edges are bent over a flame to the same angle (shown in the front view). The ribs are cut to the shape shown, with places for the spar and leading edge, then assembled with Ambroid, equidistant on the spar, carefully truing each rib on a flat surface, so the finished wing will not wind. The front edge is Ambroided in the front step, and the rear edge is Ambroided directly to the back of each rib, using pins stuck in a board to hold the edges in place while the adhesive dries. The wing end piece of bamboo is now bent to a semicircular shape, then carefully split in half, making two wing ends alike. A step is

cut in the ends of the edges in which the wing ends are neatly lashed and Ambroided. The frame is now covered with Japanese silk tissue paper, doping it to the under side first and to the upper side in two pieces so as to avoid wrinkles at the center. Pull the paper taut especially lengthwise to preserve the wing section; this is important for good flights. The wing clips are now made from No. 10 piano wire, having the center part grip the motor stick and making one ½ inch longer than the other. Lash and Ambroid the small clip to the front edge and the taller one to the rear edge, then fasten the wing in place as shown in the side view.

Flying. Balance and adjust the model as was done with the tractor shown in Figure 103; for flight the propeller may be given about 1,000 turns. When launching, release the propeller a moment before casting the model forward. This model should be capable of flying at least two minutes.

CHAPTER XV

CHASSIS MODELS

Under this heading we will consider models equipped with wheels or floats, thus enabling them to take off and alight on land or water. Such models are exceedingly interesting to make and fly, and their performance is considered separate from that of models not so equipped. Modelmakers' parlance refers to such models as R. O. G. or R. O. W., meaning "rise off ground" or "rise off water." When such a model fails to get off when launched, someone usually revives the old joke that R. O. G. means "*remain* on ground." Wheeled models used indoors are abbreviated R. O. F., meaning "rise off floor."

In Chapter I the illustration of the Cecil Peoli model shows a skid landing chassis. Skids are easily made by bending reed or bamboo or even wire, but because of the friction they do not launch a model as easily as wheels. Wheels are simple to make. Lightness is of course essential. Perhaps the wheel that best combines lightness and ease in making is a flat wooden disc. One can be marked with a compass on thin wood, cut out with a coping saw or penknife, and drilled for the axle. However, because such wheels when thin are liable to split, it is well to make two thin wheels and glue them together with their grains crossing. For the lightest job balsa wood should be used, and to provide smooth running a short piece of tubing should be Ambroided in the axle hole.

Stiff cardboard can be used also for wheels (Figure 110) and can be made less liable to bend by making a cut to the

center, then gluing the two sides of the cut together with a slight overlap like a radio cone speaker. Ambroid two such halves together, and perhaps using "passepartout" tape around the rim, serrating its edges to make it fit neatly. Ambroid a piece of tubing in the center for a hub.

Modelmakers who have access to a lathe can make very attractive wooden wheels. Use maple for scale exhibition

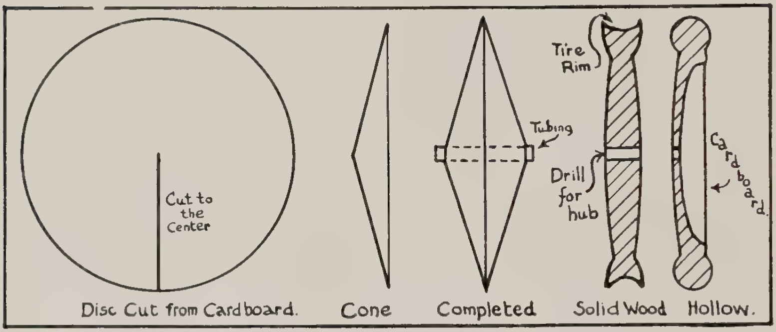


Figure 110. Wheel Construction

models, and poplar or balsa for flying models. Mount the block in the lathe between a spur center and cone center, turning down the cylinder to the desired diameter; then with a parting tool cut nearly to the center, making discs about ¼ inch in thickness. If rubber tires are to be added, cut the grooves for them. When enough discs have been made, take the stock out of the lathe, cut apart the discs, put a chuck on the headstock, mount the discs therein and proceed to turn out the shape shown in Figure 110 reserving the disc when one side is finished. If it is desired to make the wheels even lighter, cut out one side as shown, and Ambroid on it a disc of cardboard, again using tubing for a hub. If lightness is not especially desired, the rim may be turned concave and a rubber tire added.

Rubber tires (see Figure 111) are made from thin-walled tubing, cutting a piece as long as the circumference of the rim with its ends trimmed on a long bevel. These ends are next joined together, using rubber cement according to the directions

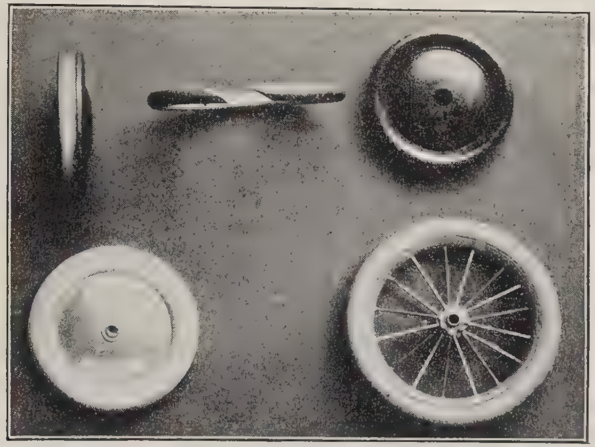


Figure 111. Types of Wheels

on the can; when dry, the tire can be slipped on, having applied to the rim a coat of cement for adhesion.

Metal disc wheels can be made by soldering together two discs of the type used when nailing down tar paper. The edges are splayed out to form a rim for a rubber tire. Frequently, on toys sold at ten-cent stores, very good light wheels can be obtained. If the wheels are half-stampings, two can be soldered together.

Model supply houses sell very attractive rubber tired disc and spoke wheels in various diameters (see Figure 111). The latter could be made by turning a hub and rim, piercing the sides of the hub and using long pins for spokes, bending at right angles below the head and soldering them to the hub and rim; but as the finished product can be purchased reasonably,

the reader is advised to buy them, unless he is intent on producing a strictly home-made job.

The struts and axles for R. O. G. models vary with the type of model frame. Struts are usually made of bamboo, split into small sizes and lashed in place after bending over the ends for attachment. On very small models piano wire can be used

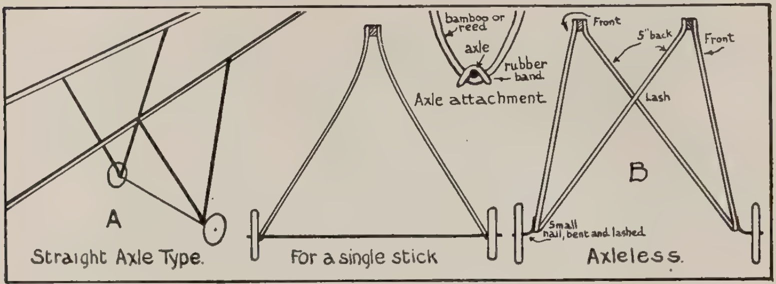


Figure 112. Wheeled Chassis

for the entire chassis frame. Figure 112-*A* shows a very simple chassis using a long axle. For outdoor flying where the model is liable to land in grass which would catch on a horizontal axle, the axleless type shown in sketch *B* is preferable. Large wheels roll easier on rough ground than small ones. The wheel axles are large pins or small nails bent for lashing to the struts.

Three wheels are sufficient for a chassis, and the custom is to use two in front and one in back, as the model in taking off and landing, rides mainly on the front. Often a skid alone is used in the back. The front wheels should be placed just forward of the center of gravity. If too far forward the tail will be hard to raise and make slow take-offs; if too far back the model will tend to nose over. (See Figure 113).

A chassis of course adds weight to a model, and this addition, together with the need for greater power to take the

model off, calls for greater thrust. Thus a chassis model would differ from a hand-launched model in having more rubber strands on each propeller, or the same rubber pulled tighter, or having propellers of less pitch or smaller diameter. Often, too, it is necessary to strengthen the frame of a chassis model to

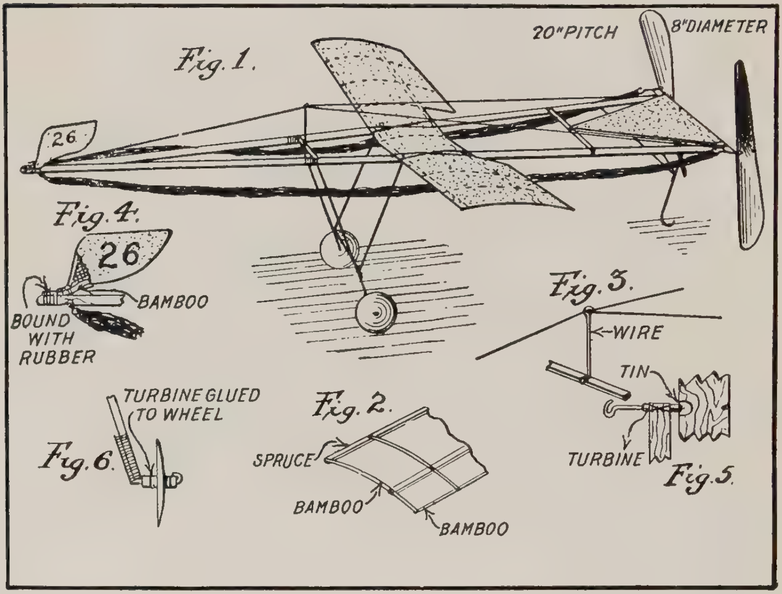
(Courtesy: Carl Fastje)

Figure 113. An R. O. G. Twin-Pusher

compensate for the added rubber and weight of the chassis, sometimes using wires as in Figure 114.

The proper way to launch an R. O. G. model, after winding, is to hold its propellers from turning as it rests on the ground, head toward the wind; then take off the hands and let it rise from a standing start. Some persons aid the model by raising the tail and giving it a slight shove, but such an act could hardly receive official sanction. A smooth take-off area is desirable, a platform being made if necessary, as was done for the First Miniature Aircraft Tournament, held at Memphis under the auspices of the Playground and Recreation Association in 1927. A strip of linoleum makes a good take-off area. Measurements of distance and duration flights should be made

from the moment or point of take-off until the model next touches the ground, *not* from the moment of release to the time the model stops rolling after its landing.



(Courtesy: Major Ernest Jones)

Figure 114. An R. O. G. "Sizzlefoot"

R. O. W. Models

The construction of floats for rise-off-water models calls for knowledge and care, but is not necessarily difficult. Years ago floats were made box-shaped with flat bottoms, but it was found that these were hard to take off with, owing to the suction of the water for the flat surface. Also they had a high air resistance. This brings us to realize that an ideal float should have minimum water and air resistance. A satisfactory float is illustrated in Figure 115, where the

four views make its construction plain. The parts are made of thin balsa-wood slats and square struts. It is covered with silk, doped and varnished. The size will vary with the model

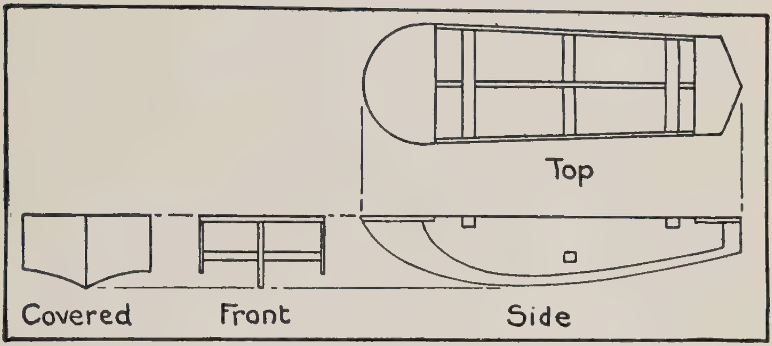


Figure 115. Balsa Slat Float

to be floated, but for guidance it may be stated that two 4½-inch floats in front and a 5½-inch one in back should support a 3-foot scientific model. In order to decrease the water-pull

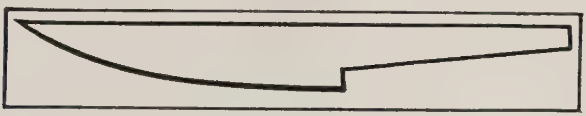


Figure 116. A Stepped Float

on the under surface, some constructors may prefer to make a "step" in the float bottom. That can easily be done by shaping the sides like Figure 116 and putting in a thin slat for the step riser.

Figure 117 shows another type of float made of bent bamboo. The three views show how the three bamboo frames are formed and joined together, using thin strips of bamboo bent over a candle flame and Ambroided at the joints, then

covered with silk or paper, doped and varnished. Some may prefer to make the center piece of a thin balsa slat.

Floats are attached to the model frame with thin bamboo struts, using Ambroid for adhesive and when needed,

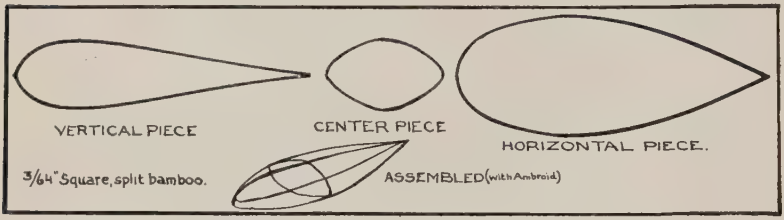


Figure **117.** Bamboo Frame Float

strengthening the attachment with lashing. Sometimes a strut is attached to a float by sewing with a needle over the strut and into the fabric side, later closing the stitch-holes with Ambroid. Figure 118 shows the float arrangement for a twin-

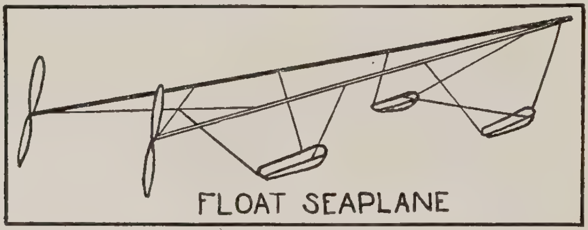
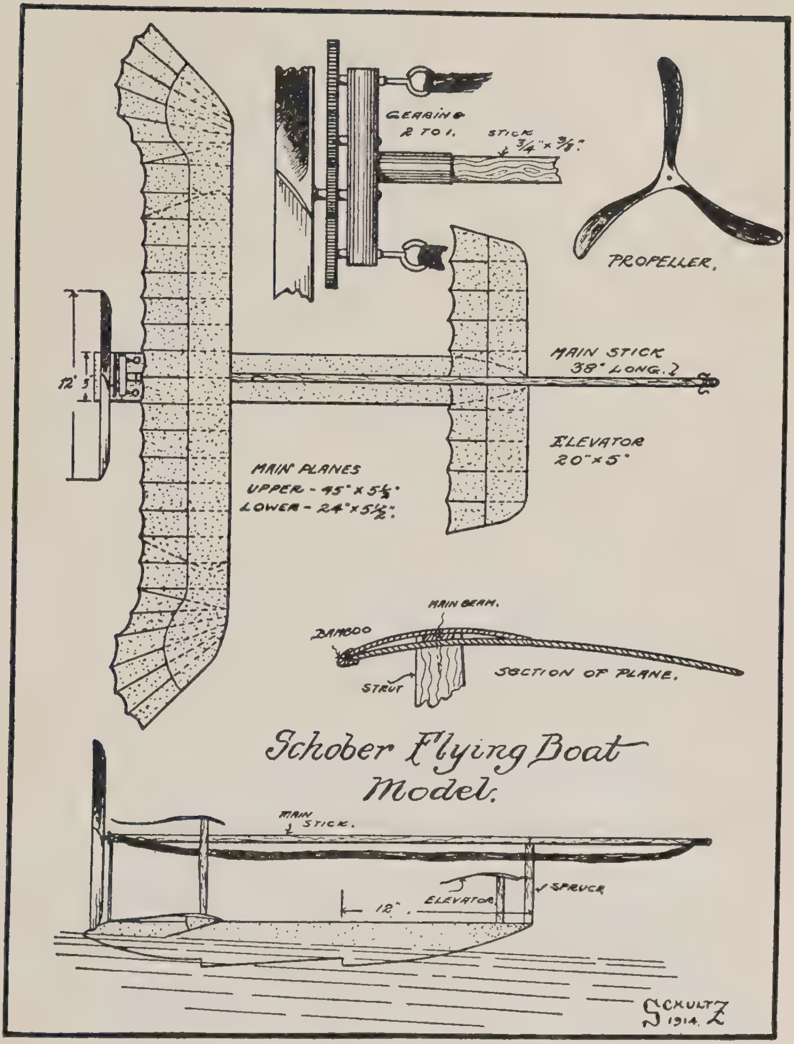


Figure 118

pusher frame. Figures 119 and 120 illustrate a single large float used for support. In such models extra floats for balancing are usually added to the main wing tips.

The author recently made a hydro model in which the floats were assisted in their function by the addition of vanes at the sides. The result was a model which made remarkably quick take-offs. The idea is shown in Figure 121. As is the



(Courtesy: Major Ernest Jones)

Figure 119

case with R. O. G. models, additional thrust is needed for hydro flights; this thrust is obtained in the same manner as that specified for models with land chassis.

Bertram Pond, of Peru, Indiana, holds the present world record for hydro models with a flight duration of 2 minutes,

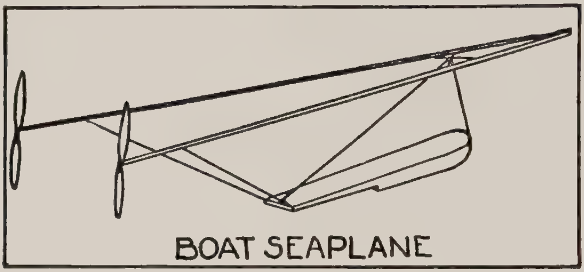


Figure 120

52 seconds. Flying a similar model his friend Virgil Rassner won first place at the 1927 Tournament. Rassner has kindly furnished the author with the following specifications of his

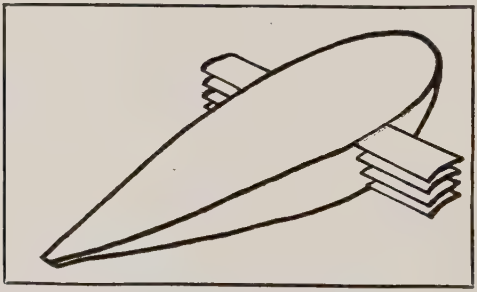


Figure 121. Float Vanes

model. Its construction follows the general lines of twin-pusher, three-float hydros but owes its superiority to lightness and accuracy of construction. The floats were similar to those in Figure 117.

FUSELAGE:

A-frame 38 in. in length, 12 in. in width
Balsa longerons
2 straight and 3 X-braces of split bamboo

POWER:

2 11-1/2-in. balsa propellers, driven by rubber strands

WING:

Span 28 in., chord tapering from 5-3/4 in. at center, single surface
Dihedral 2 in. at tips
Ribs 3/64 in. square bamboo
Front edge 1/4 x 5/32 in.
Rear edge 3/16 x 1/8 in.
Covered with Japanese silk tissue paper, doped before covering

ELEVATOR:

Span 14 in.
Chord 3-7/8 in.
Dihedral 1-1/4 in.
Ribs 1/32 x 3/64 in.
Bamboo edges 1/16 x 3/32 in.
No keel surface or rudder.

WEIGHT:

2-7/8 ounces

PERFORMANCE:

1 min., 5 sec. The flight at Memphis was not its best flight.

Hydro models are launched from the surface of a smooth, large body of water and at the take-off are headed into the wind. If the situation should arise where no lake or river is available for hydro model flying, a large tank can be substituted, but of course the model would alight on the land; however, if high grass covers the ground it will cushion the landing.

At the suggestion of the Honorable Edward P. Warner, Assistant Secretary of the Navy and a member of the Committee in charge of the National Playground Miniature Air-

craft Tournament, an indoor hydro model contest was inaugurated in connection with the 1928 tournament. An entry for this event would be a small, light twin-pusher, or an indoor tractor such as that described in Chapter XVI, either being equipped with three floats, about 2½ inches in length. Indoor hydro launchings would naturally be from a tank.

CHAPTER XVI

A TRACTOR MODEL FOR INDOOR FLYING

An interesting form of competition for model-aircraft makers is an indoor flying contest. Back in the early days of model aeronautics practically all of the contests were held indoors because, as the models were not able to perform in any wind, and as their flights were of short duration, a large building offered the best accommodations. It also provided arrangements for spectators. Many of the modelmakers who are "old-timers" recall the enthusiastic crowds that thronged the New York Armory, about fifteen years ago, to watch the competitions held there with the small aircraft. They were an appreciative audience that applauded successful flights or audibly sympathized with the unfortunate. Under the combined stimulus of keen competition and deserved praise the contestants rapidly improved their models so that soon flights were being made for the entire length of the block-long building. Then the boys wished to give the models better opportunity to exhibit their full powers for which reason subsequent contests were held outdoors.

Lately, however, indoor model flying has been resumed. For the contestant it opens up an opportunity for a type of model different from the outdoor flyer and provides entertainment for the winter months when harsh weather makes outdoor flight difficult. From the spectators' point of view model flights have always been interesting to behold, but trips of a mile or two are impossible to follow from a grandstand and few spectators have enthusiasm or physical ability for running after the model.

The type of model used indoors may be lighter and smaller than outdoor types. Distance is not the desired result because in these days of distributed knowledge practically anyone can make a model that will fly from end to end of the largest buildings, consequently duration is established as the objective; to attain it the model must fly slowly and maneuver correctly. The type of model that has proved most successful in these qualities is that described in the following paragraphs. Its development is largely due to the efforts of John Considine and Merrill Hamburg who are efficient recreation and education leaders of Detroit and have sponsored a widespread interest among boys there in model aeronautics. The following directions have been prepared from specifications courteously given the author by Mr. Hamburg. These materials are necessary:

WOOD:

Fuselage and Empennage:

1 piece balsa, 15 x 1/4 x 5/32 in.
1 piece bamboo pole, 12 in.

Wing:

2 pieces balsa, 18 x 1/8 x 1/16 in.
Bamboo

Propeller:

Balsa, 10 x 1-1/4 x 3/4 in.

METAL:

1 propeller nail bearing
2 cans
1 tail-hook
1 shaft
2 washers
2 wing clips

FABRIC:

1 sheet Japanese tissue paper, 20 x 12 in.
Silk thread for binding
32 inches of rubber thread, 1/8 x 1/32 in.

Liquid:
Ambroid for adhesive
Banana oil for surfacing

Construction of Fuselage and Empennage. First make the metal fittings. These should be of the type shown in Figure 122, and are similar to those described in Chapter VI, but for this indoor model they may be lighter than those used for outdoor models. The bearing is made from a small brad and bored with a No. 65 drill. The cans are bent as shown from .015 music wire; the tail-hook is bent from .020 music wire; the shaft is the same size, and the washers should be small dress spangles about 5/32 inch diameter. The wing clips are made as shown from .015 wire, their center portion fitting the fuselage stick; the clip on the right intended for the back of the wing is to be ½ inch higher than the other. Wire fittings also may be made from unwrapped steel guitar strings.

The fuselage stick which is 15 inches in length is tapered from the center where it is ¼ inch deep to the ends where it is 5/32 inch square. This tapering is done by laying a metal-edged ruler on the stick and cutting off the taper along the straight edge with a sharp knife or razor blade. When finished, smooth it carefully with sandpaper and paint with banana oil to stiffen it. The propeller bearing and tail-hook are lashed and Ambroided to the ends and the cans are Ambroided 4½ inches from each end. Make sure that a sight taken from the tail-hook to the bearing hole will pass through the center of the cans.

Empennage is an aeronautical term meaning tail surfaces. To make these, split from the bamboo a piece 12 inches in length and 1/16 inch square. Draw on a piece of paper a full-sized picture of the rudder and bend the bamboo over a small flame to conform with the pattern, repeatedly laying the piece over the paper to be sure the bends are correct. The bamboo

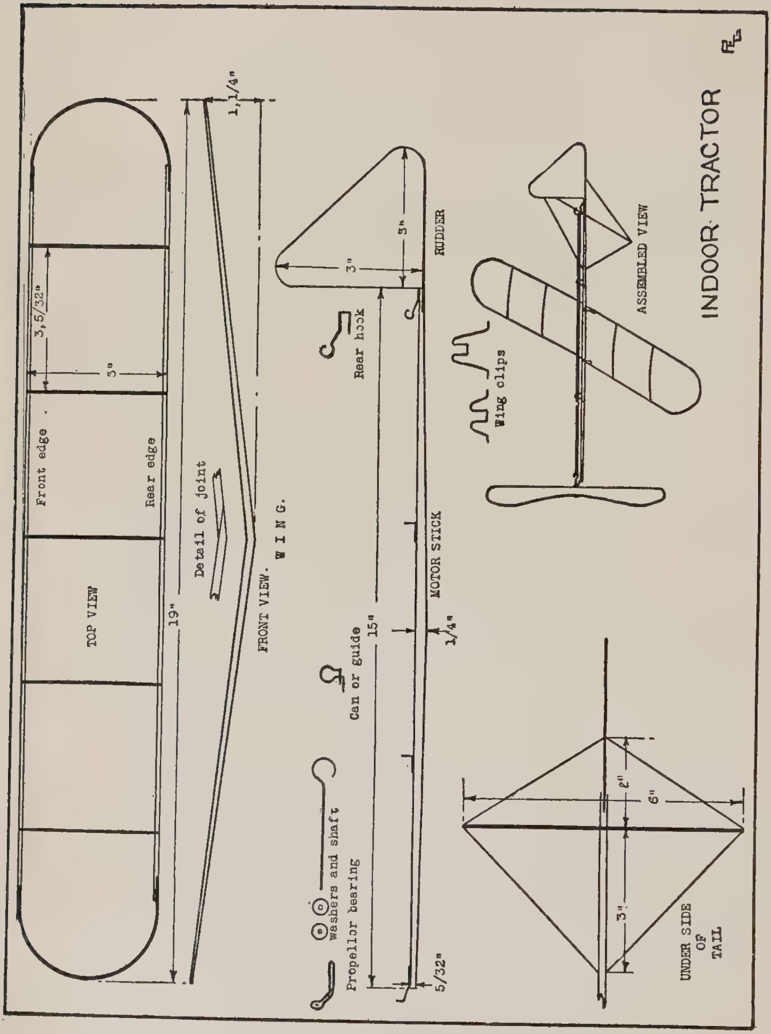

TOP VIEW
Front edge
Rear edge
3,5/32"
3"
19"
1,1/4"
Detail of joint
FRONT VIEW.
W I N G.
RUDDER
3"
3"
Rear hook
MOTOR STICK
15"
1/4"
5/32"
Can or guide
Washers and shaft
Propeller bearing
Wing clips
ASSEMBLED VIEW
UNDER SIDE OF TAIL
2"
6"
3"
INDOOR TRACTOR

Figure 122

must be uniform in size or the bends will be irregular. When finished, carefully trim the bamboo down to a smaller size, about 1/64 x 1/32 inch, the thin section being parallel to the drawing. Notice that the rudder's bottom edge is formed with an extension of about ½ inch for fastening it to the fuselage stick, which is grooved to receive it. It is fastened therein with Ambroid. For the elevator, a piece of bamboo 6 x 1/32 x 1/64 inches is Ambroided on the under side of the motor stick ¾ inch from the back end. A piece of thread (about 18 inches) is tied at its center to the bottom edge of the vertical rudder and the ends are stretched taut around the ends of the bamboo strip and tied to the fuselage stick 3 inches from the strip, forming a diamond-shaped area as shown in the detail drawing.

The rudder and elevator are now covered with paper which should be previously ironed out if wrinkled, and allowed to cool to the room temperature before using. The rudder is covered first. This is done by cutting out a piece of paper slightly larger than the rudder outline which is then painted with banana oil and the paper laid on it, care being taken to smooth out all wrinkles. If the banana oil is not thick enough to make the paper adhere, it will become thicker if left open to evaporate a little. When covered, the paper is trimmed and the rough edges smoothed over with another coat of banana oil. The elevator is covered in the same manner although the paper is not trimmed close to the thread but at a distance of about 1/32 -inch margin to allow the banana oil a better chance to hold. Finally, be sure the surfaces are flat and perpendicular to each other.

The Wing. The wing has a slight dihedral or upward angle to give it stability. This is imparted to it in forming the spars, which can be bent by heating, steaming or cutting.

The first method is similar to that used for bending bamboo; the second substitutes the steam issuing from a teakettle spout for the flame, and the third is explained in the drawing "Detail of Joint," where the spar has been cut at an angle and rejoined. The angle should be the same in each spar and should be such that the ends are 1¼ inches higher than the center.

For the ribs, a single piece of bamboo 3 x 3/16 x 1/32 inches is used and from it 5 straight ribs are split, 1/64 inch in thickness. These are Ambroided in place, equally spaced as shown, making a ladder-like frame. The wing ends are bent from a piece of bamboo 5 x 1/16 x 1/32 inches, which, after being bent to a semicircular shape, is carefully split in half to form two identical ends. These are Ambroided in steps cut in the ends of the wing spars, completing the frame.

The wing clips are now lashed and Ambroided in place, the higher one to the rear edge. They must be properly bent before attachment as they can not be changed afterward without endangering the wing. Now take the Japanese tissue and carefully cut out the center of a piece to fit between the clips, but slightly over-large otherwise. The paper is fastened with banana oil, beginning with the center rib which is painted with oil and the paper attached. When dry, proceed outward by sections allowing each to dry before continuing; work carefully to insure smoothness. When completely covered, the edges can be trimmed and painted to smooth them as was done with the rudder.

The Propeller. The blank, after being carefully faced up so that its sides and edges are square, is marked out by drawing lines from corner to corner diagonally, and at their intersection a small hole is drilled to take the shaft. Because of the softness of balsa wood, the hole can be made with a pin, if

care is taken to push it through perpendicularly. At the intersection, a small hub is left; the remainder of the propeller is cut out on the diagonals as is described for the Langley propeller in Chapter V. As explained in that chapter, the

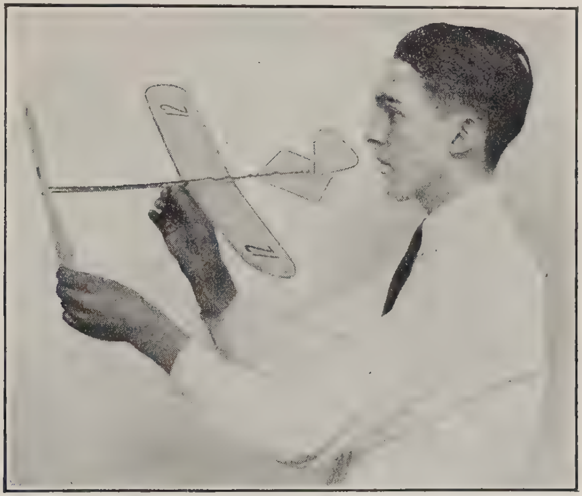


Figure 123. Conant Emmons (Capitol M. A. C.) with His Indoor Tractor

propeller is carved, cutting the blades with a slight curvature and finally reducing them with sandpaper to a thinness that shows pinkish when held to a light.

When completed, the blades must be not over 1/32 inch, slightly thickening to the hub which should not be more than 3/32 inch in width where the shaft goes through. Do not leave the blades in the Langley shape but round off the ends evenly as shown in the assembled view. The shaft is passed through the hub, with the hook on the concave side. The protruding end is bent over for ¼ inch at right angles and Ambroided in place. Two small washers are used between the hub and the bearing to reduce friction. They should have a

drop of oil on them. After passing the shaft through the bearing, tie the ends of the rubber thread together with a square knot and hook the loop on the shaft; reeve through the cans and fasten to the tail-hook. If a winder (described in Chapter XIII) is used, an S-hook can be attached to the rubber loop.

Assembly and Flying. Some modelmakers like to add a skid to the plane to give it stability and protect the propeller when landing. If desired it can be made from bamboo, 7½ x 1/32 inches square bent over for ½ inch at right angles, for attachment to the fuselage stick, and turned into a J shape at the other end. The whole should be sufficiently long to permit the propeller to clear the floor. The wing is fastened to the fuselage stick by the clips, placing it as shown in the drawing. You will now see that the higher wing clip at the back gives the wing an angle necessary to flight. To adjust the placement of the wing, glide the model. If it dives, set the wing forward slightly and try again. If the model tries to climb and stalls, set the wing slightly farther back. When the plane glides evenly, it is ready to be wound and flown.

To make the model curve in flight, the rudder may be bent by breathing on it and bending as the warmth of the breath warps the bamboo. The amount of curvature depends on the size of the room in which it is flown. The number of turns imparted to the rubber can best be determined by experiment, 750 being used for a first trial. This model when finished ought to have a duration of at least 100 seconds. At the first National Playground Miniature Aircraft Tournament, John Rappold of Chicago flew this type of model for a duration of 2 minutes, 9.6 seconds and was tied by Jack Loughner of Detroit. The lowest duration for this type was 98 seconds. On a very calm day these models can be flown outdoors.

CHAPTER XVII

SCALE MODELS

The term "scale model," which means the same as "commercial model," is generally applied to three distinct types, classed as fuselage scale models, flying scale models and exhibition scale models. All three sub-types are more or less reproductions of existing man-carrying models, embodying a fuselage, chassis, wings and control surfaces, thus differing from scientific models which have merely a wing, elevator and simple frame. Fuselage scale models are the least accurate reproductions, the fuselage being a simple triangular or square frame, the landing gear a light bamboo or wire frame, the wing being similar in construction to those used on scientific models, and the tail surfaces resembling those on a hand-launched scientific tractor. The wing of such a model can be moved about to properly balance the model, in some instances being quite a distance back from the propeller.

Flying scale models closely resemble an original man-carrying machine; they have similarly shaped fuselage with cockpits, similarly shaped landing chassis in the same relative position as the original, wing or wings of the same relative size and shape in the same position as on the original, and movable control surfaces similar to those on the original. The only leeway permitted is with the propeller. This may be larger than the scaled-down original, but its rubber or other power must be in the fuselage. Because of the different distribution of weight between the model and original, the only way in

which the model may be accurately balanced is by proper setting of the controls or by adding weight to the nose in case the controls do not hold the model in equilibrium.

Exhibition scale models are not intended to fly; they are made in exact imitation of the prototype. The fuselage, chassis, wing and control surfaces are exactly the same as the

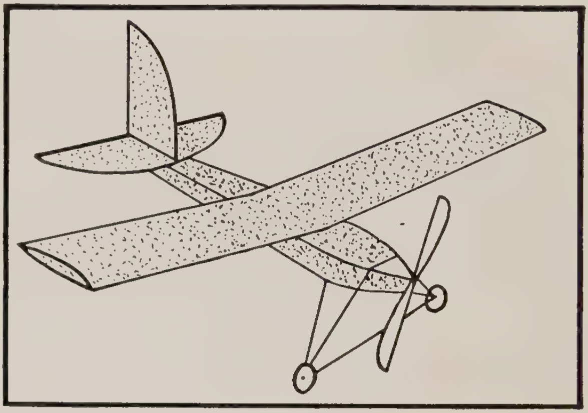


Figure 124. Fuselage Scale Model

original regarding both shape and position. Such features as a dummy engine, exhaust pipes, cockpits with miniature seats and instrument board with the joy stick and rudder bar actually working the control surfaces; wind shields, complete wing bracing and other parts, are added to complete the realism. These models are purely decorative and educational.

Wind tunnel scale models will not be mentioned here as they are outside the realm of model aeronautics as a sport, being used for aerodynamic purposes only. They are referred to in Chapter XXIV.

Fuselage Scale Model

Figure 124 shows a representative fuselage scale model. It is of the type brought out by Wm. Atwood, of Riverside,

California, when a contestant at the first P.R.A.A. Tournament at Memphis in 1927. The model flew exceptionally well, taking off under its own power and making several flights of about half a minute.

The fuselage is formed of three longerons which are curved by the following process. Wrap the three pieces of pine or

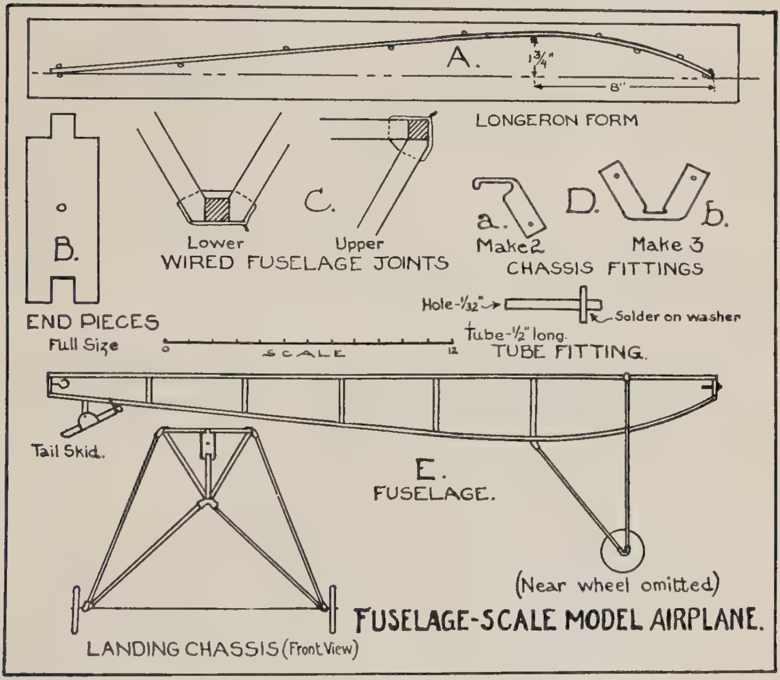


Figure 125

spruce each 28 x ⅛ inches square, in a cloth wrung out in hot water, and place over a shallow wide pan of boiling water, so that the steam from the water will keep the cloth and sticks hot for 40 minutes. Meanwhile prepare a form by driving nails in a board as shown at *A* in Figure 125, and when the wood is taken from the cloth, lay the pieces, one above the other around the nail form, keeping them in place with other

nails. Allow 24 hours for drying, then when removed they will retain the curved shape. Make two pieces like *B,* and fasten the three longerons together to form a triangular fuselage with the pieces *B* at each end. Now, from 1/8 inch square wood cut 18 fuselage braces, six for each side and the top, placed 4 inches apart. Cut the ends to fit snugly against the longerons, and join each group of three with three wires, using Ambroid for adhesive. A wired joint, made by drilling small holes near the end of each brace and stringing around the longeron with No. 32 wire, is shown at *C*. Next, procure 4 1/4 inches of thin-walled metal tubing 3/32 inch inside diameter, and from it make the fittings shown at *D,* pinching the flattened parts with pliers, and drilling small holes in the ends for retaining nails. *E* shows two views of the fuselage with the fittings just made, in place in the landing chassis. The two fittings *D-a* are lashed at the top, one of the type *D-b* is lashed on the bottom, located one panel in back of the others, and the other two form the bottom joint of the struts. The struts are made of bamboo to go in the fittings. For types of wheels see Chapter XV.

The tail skid is made of a straight piece of wood, 2 inches in length, with a strap of thin metal lashed to it and hinged to a short post. At the front end of the skid is a rubber band held in a notch and carried over the lower longeron. Through the hole in the front of the fuselage a tube fitting is placed and Ambroided, and through the hole in the back a hook is placed with its projecting end lashed to the wood. Now the fuselage can be covered. Use tissue paper or China silk for the fabric, and dope or banana oil for adhesive; cover in three pieces, one for each side, one panel at a time, cutting out places for fittings when they are encountered, leaving the back panel open on all three sides and the front panel open on top.

The stabilizer (Figure 126-*A*) is formed of a wooden back piece 13 x ⅛ x 1/16 inches, bamboo rim, and wood braces, to the dimensions shown, covered on one side and wired to the back top of the fuselage. The rudder, *B*, is formed of a

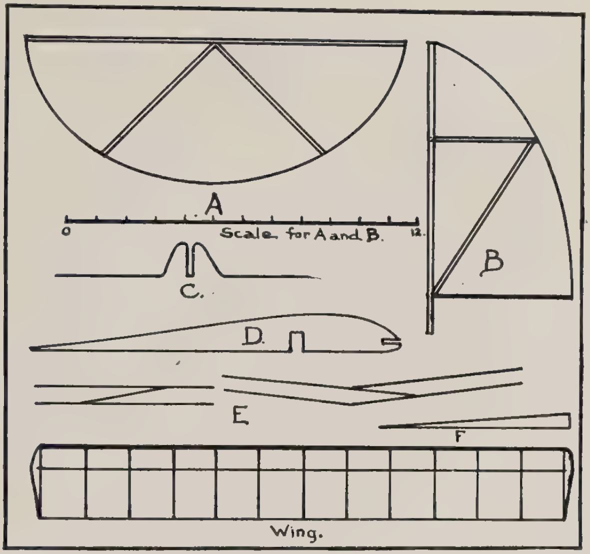


Figure 126. Surface Construction

wood upright 10 x ⅛ inches square, at the rear with a bamboo front rim and wood base piece, 5 x ⅛ x 1/16 inches, the three wired together and cross-braced with wood. The rudder is then covered. The inner side of the upright is rounded off and wired to the back piece so that it can turn. A clip is made as shown at *C*, with the opening to fit tightly on the rudder base piece, the two long ends are wired to the front of the stabilizer. The upright is wired on, the front of the rudder is clipped in this fitting, and by moving the clip from side to side the rudder can be turned.

The wing is formed from 15 ribs 5 inches in length, cut to the pattern shown at *D* from 1/16 inch balsa, assembled on a

spar 36 x 3/16 x 1/16 inches, which has been previously cut in the center at an angle and rejoined as at *E*. Ambroid is used for adhesive. Two edges, 36 x ⅛ x 1/16 inches, are bent to the same angle as the spar by holding them above a candle flame

(Courtesy: W. C. Bechtold)

Figure 127. Miss Mae Barton and Her Model. The only girl entered in the airplane contest held at Evanston, Illinois, September 4, 1927

and bending as the heat softens the fibers. The front edge is Ambroided in the rib nose slots, the rear edge is Ambroided against the rib ends, and the remaining two ribs are Ambroided to the ends of the frame. The whole is now covered, first on the bottom with a single piece of fabric slightly larger than

the frame, fastened to one panel at a time and pulled taut without wrinkles. The top is covered in two halves, beginning at the center, pulling taut especially lengthwise to preserve the true wing section.

The propeller is carved according to the directions in Chapter V, from a balsa blank, 13 x 1⅛ x ¾ inches. A shaft is

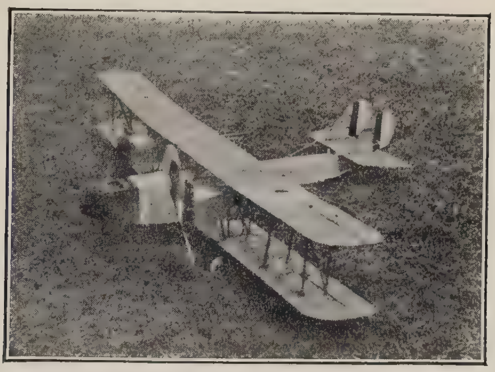


Figure 128. A Martin Bomber Model by Luther Bechtel of Haddonfield, New Jersey

made from No. 15 piano wire, inserted in the tube bearing from the inside of the fuselage, three small washers are put on the projecting end which is then passed through the hub of the propeller, bent over and Ambroided down. The motor is made of ten strands of ⅛-inch flat rubber stretched from the shaft-hook to the tail-hook.

The wing is attached with a rubber band passed over the wing and around the fuselage. Small blocks like those shown at *F* are used to steady the wing and give it incidence. The wing is placed approximately where shown, and the model tested. Turn the propeller about thirty times, in the direction opposite to that which it will take in flight. Hold the model level, release the propeller and hand-launch it gently forward.

If it climbs and stalls, move the wing back; if it dives, move the wind forward. When correctly adjusted, smooth, even flights will result, and then the model can be launched from the ground on its own chassis, giving the rubber more turns. If winding the propeller should distort the fuselage, it may

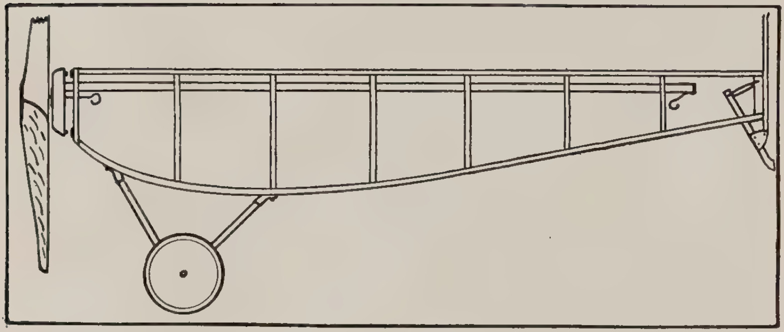


Figure 129. Fuselage with Motor Stick

be corrected by adding a motor stick. Figure 129 shows a fuselage with a motor stick. Its front end is fastened to the nose and rear end loosely hung to a cross strut so it is free to turn. In this way the stick twists with the rubber torsion, but the fuselage remains true. Various ingenious ways have been developed enabling the motor stick to be removed while winding; in this manner a geared winder can be used, storing more turns in the rubbers. Dress snaps, wire clips, screw clamps, etc., are used for detaching the motor stick.

Flying and Exhibition Scale Models

Having thus been initiated into the making of a simple fuselage scale model, a general treatment of making flying scale models and exhibition scale models will be discussed. The first step is to decide upon the design that is to be made. It usually follows the modelmakers' attraction for some particular plane. After the round-the-world flight in 1924, there was

an epidemic of Douglas cruiser models and after Lindbergh's flight almost every boy wanted to make a "Spirit of St. Louis." So it goes. Having chosen the ship proceed with obtaining data upon it. The best source is the manufacturer of the plane,

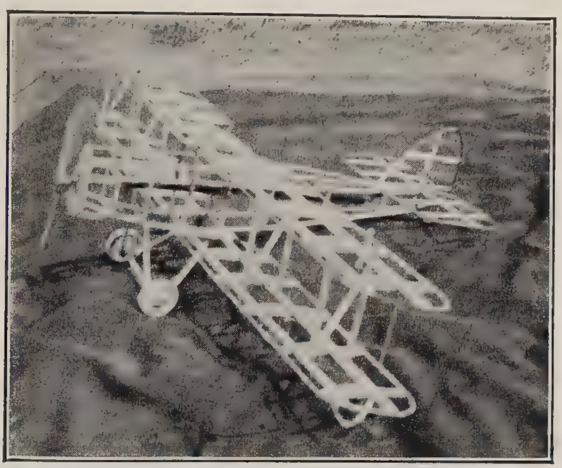


Figure 130. A De Haviland Model Frame

who will probably be glad to send blue-prints from which you can scale the drawing. Aeronautical magazines frequently carry outline drawings and detail photographs of prominent planes. The Aircraft Year Books, published by the Aeronautical Chamber of Commerce, have numerous outline drawings in the back of each issue; these books have been appearing annually since 1919. Model supply houses carry numerous blue-prints and drawings of models. In a pinch, photographs can be used if a few dimensions are known.

Next decide upon what scale you are going to make the model. Three-quarters of an inch to the foot is a good general size for almost any model. A draftsman's scale is helpful in the next step, the making of a drawing, in which every part is drawn to the size that it will be in the finished model.

The scale aids in determining the size of parts in the original source of information, also in plotting the model drawing. Sometimes the original drawing will have the scale indicated in it.

Now proceed with the construction of the various parts; it is customary to make the fuselage first. Model work follows

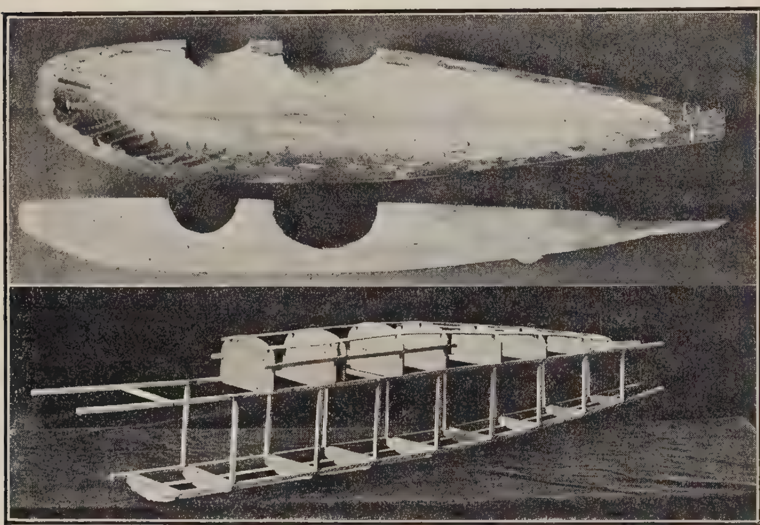
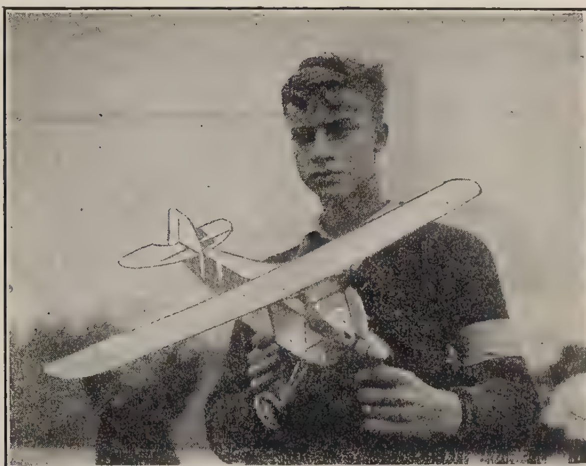


Figure 131. A Hollowed Wood Fuselage for an 18-T-Triplane Model and One Built Up for a Douglas World Flyer Model

the general practice for full-sized machines, so far as framing is concerned, as indicated by Figure 130, but occasionally a departure is made. Sometimes the fuselage or wings are made from solid wood shaped with a draw knife, spoke-shave, plane, file, and sandpaper. For lightness the fuselage is often cut in half longitudinally, then shaped, hollowed out, and glued together. (See Figure 131.) Sometimes a cylindrical fuselage is made from a paper tube cutting out long V-shaped pieces to taper it. Others are built up of papier-mâché or gummed tape

wrapped about a form. When the longeron and spar system is used, these may be made of pine, balsa, soldered wire, or bamboo, the latter being easily split to size, bent to shape, and Ambroided in place. It is customary to so place the fuselage struts that they can resist the shocks imposed upon the landing chassis, wing struts, etc. Combining the tail-piece and



(Courtesy: Bertram Pond)

Figure 132. An Efficient Bamboo-Framed Flying Scale Model Flown at the Memphis Tournament, 1927, by Tudor Morris

rudder post is also a good idea. The chassis, wing struts, etc., are easily attached through use of metal tube fittings, already described. Cockpits are put in the top of the fuselage by adding a turtle-deck with openings. (See Figure 131.) The cockpit rims are formed of bamboo or reed, bent to a saddle shape by heating or steaming.

When it is necessary to add weight to the nose of a model for balancing, it is preferable to add some feature of the original machine, rather than merely tying on a piece of lead. A dummy engine serves well in such cases. Stationary en-

gines may be upright, Vee, "W", opposed, "X" or radial, and can be imitated on a model by Ambroiding little pieces of wood, doweling, etc., to the front of the model. "Plastic

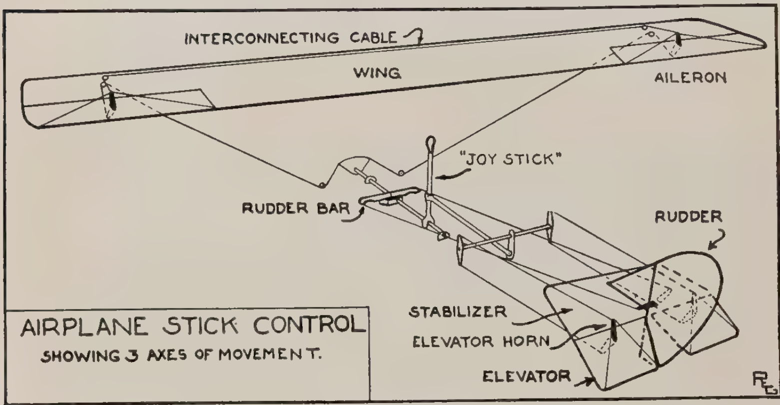


Figure 133

Wood," a sporting goods and hardware store product, can be worked like putty to any shape; it hardens like wood and contains its own adhesive, thus being excellent for dummy engines, spinner caps, head rests, stream line fairing, etc. Exhaust stacks are made of reed, doweling or tube. Rotary engines are made of balsa or maple doweling Ambroided to a hub which is fixed to the shaft of the propeller to revolve with it. In the case of exhibition models, a little "drink mixer" electric motor is sometimes housed under the engine hood to

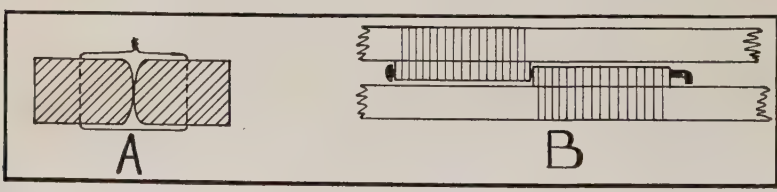
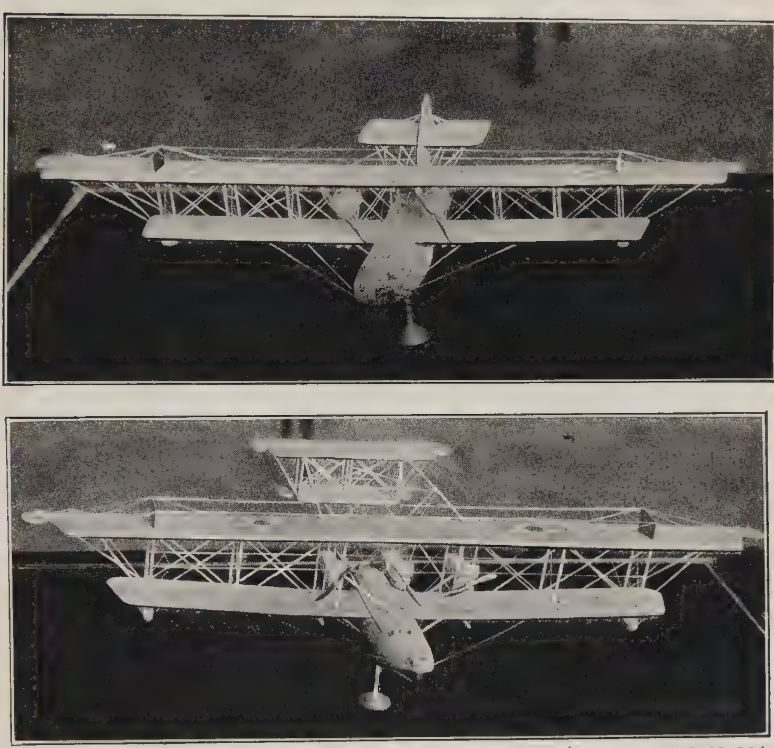


Figure 134. Hinges

turn the propeller. Wind shields, windows and other transparent parts can be made of celluloid or "Cellophane."

If it is desired to construct the cockpit with a seat and controls, Figure 133 shows the standard hook-up for controls,



(Courtesy: U. S. N. M.)

Figure 135. An F5-L and an NC-4 Model in the U. S. National Museum

although any method may be used to produce the same movements. The wings and control surfaces themselves can be made of built-up frames as for previously described models, or the same method may be used with soldered tube or wire. On some models solid wood wings and surfaces are used. Hinging of elevators, rudders and ailerons varies with the in-

genuity of the modelmaker. Some merely use a piece of wire as in *A*, Figure 134. Another way is to attach little tubes to each adjoining part with a pin, wire, or nail for an axle as in *B*. To be accurate, the same wing section should be used in the model as in the original. Chapter XIX on Design and Methods contains helpful data on scaling down wing sections. Wings can be attached by screws through their spars into the longerons, by clips, by wiring, by rubber bands, nails, etc. In the event of a biplane or triplane, the strut connections are best made of tube fittings. (See Chapter VI.) In some instances the struts may be inserted in holes in the wing spars. To allow for wire connections, small strips of metal with a hole in each end are fastened under the strut connection. The wires greatly assist in steadying and securing the wings.

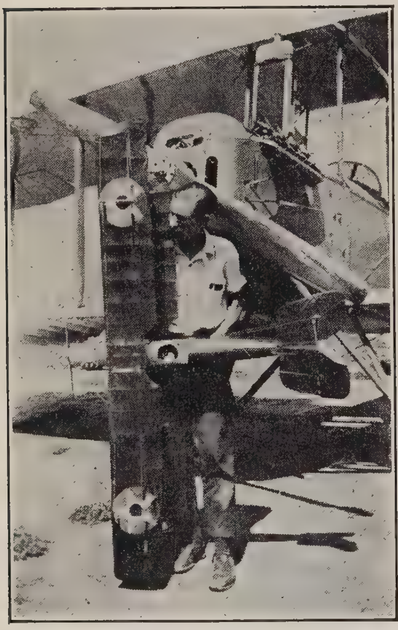


Figure 136. Clarence D. Glanton Holding the Model Described in the Text

When a model has been completed in all its parts and assembled, the resemblance to the original can be intensified by various markings and decorations. The cocardes are the outstanding decorative features of military planes, and they either can be painted directly on the wings or on thin paper which is pasted to the surfaces when dry. The stripes and markings on the rudder can be painted on, likewise those on the fuselage. Should the modelmaker be a poor letterer, small gum-backed

letters in all sizes and shapes can be bought in stationers' stores. Dennison stores carry numerous colored papers, circles, stars, etc., adaptable to the original markings on aircraft.

Glanton's Scale Model

Several examples of scale models are shown as illustrations for this chapter, and several others are shown throughout the

Figure 137. Carl Fastje's JN Model

book. The model Curtiss JN4D-2, illustrated by Figure 136, was made by Clarence D. Glanton, of Los Angeles. It is an excellent exhibition model and has flown when equipped with 100 feet of 3/16-inch flat rubber. It is built to 1/7th scale, having a span of 73⅝ inches; length 47 inches, height 16¼ inches, chord 8⅜ inches. It uses the Eiffel-36 wing curve as does the original. When used as an exhibition model equipped with a 3-pound electric motor (a G.E. 1/200 horsepower, 2,200 revolutions per minute); it weighs 6 pounds, 6 ounces. With rubber it weighs 4 pounds.

Construction details are as follows: silver spruce longerons 5/16 inch square; uprights and cross-pieces of same, fuselage

nailed, glued and wired. A pendulum device installed in the rear cockpit maintains automatic stability and operates the controls. The turtle-back is separate, composed of 11 strips and five bulkheads, being detachable for making adjustments to the interior. The landing chassis is made of spruce struts, ⅛-inch steel tubing axle, 3⅝-inch aluminum disc wheels with rubber tires, all secured with aluminum fittings. A swiveling oak tail-skid is used. The dummy OX-5 engine consists of 117 pieces of steel, copper, brass, aluminum, tin and wood. The electric motor is mounted back of, and below, the OX-5, connecting with the propeller by means of a 5-inch steel shaft, running in nickel-babbitt bearings with oil sumps, so that continuous duty is possible when on exhibition. A small fan on the motor shaft assists in cooling. The propeller is 14⅝ inches in diameter, weight ⅝ ounces, and has copper tips, painted silver and Valsparred, secured by three hub bolts and finished with a brass spinner. The radiator is hammered copper with screen soldered inside. The engine cowling is No. 20 sheet aluminum with vents pressed open and an inspection door on each side which permits sufficient space to oil the bearings. The cockpit is No. 34 aluminum with rubber padding and windshields of celluloid. The tail has a spruce frame, 3/16-inch reed entering edge, and 1/16-inch aluminum wire trailing edge, with special hinges permitting a 45-degree swing from center.

There are cast aluminum horns on elevators, rudder and ailerons. To attach the horns, each was drilled and tapped for a 2-56 machine screw, then a bolt minus head was pushed through the control with ¼ inch protruding, upon which the horns were screwed up, making a neat and substantial job. The wings are built up, having ribs 2 inches apart, wing spars of ¼ x 3/16-inch spruce, ⅛-inch aluminum rod for entering edges, and 1/16-inch aluminum wire for trailing edges. The wings are guyed by the proper landing, flying and drift wires,

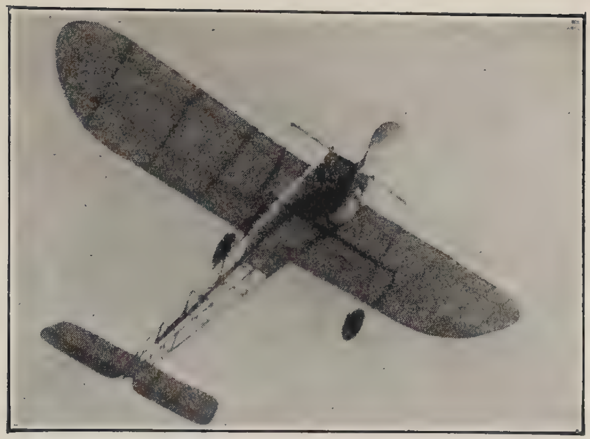


Figure 138. Bleriot XI Made by Christy MacGrath

with turnbuckles having ¼ inch pull, making a rigid job that is taken down and set up the same as the original. The ailerons have a 40-degree radius from center.

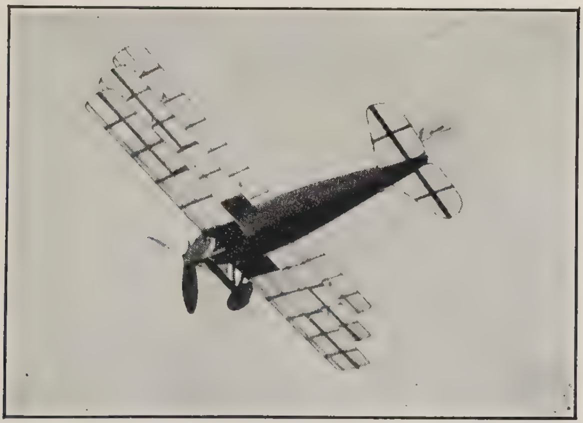


Figure 139. An 18-T Triplane Model by Carl Fastje

Number two, 56-thread machine bolts are used throughout, the covering is a light cotton, doped with three coats and painted olive drab. Every part and every fitting is home

Figure 140. Fastje's "Columbia"

hand made. Mr. Glanton, to whom the author is indebted for the above description, has named his model "Looping Lillian"

Figure 141. Emmon's "Hawk"

and says it has paid for itself many times over, despite the fact that it took 400 hours tedious work covering a period of three years and an expenditure of almost $100. He has fre-

quently used it in motion picture work, both for simulating the action of full-sized machines and for exhibition in theater lobbies where air movies were being shown. Captain Nungesser, the famous ace whose fate as a transatlantic flier saddened the world, while appearing in a motion picture saw this model and declared it to be a handsome piece of work. Mr. Glanton is himself a flier, hailing from Roger's Airport, Calif.

Other Scale Models

Bob Sommers and Christy MacGrath, of St. Louis, have fine reputations as modelmakers, both in scientific and scale types. Examples of their work are illustrated in this book.

Carl Fastje, of Denison, Iowa, being a native of the same town as Clarence Chamberlin, the noted transatlantic flier, is naturally interested in the *Columbia*, Bellanca monoplane in which Chamberlin and Levine made their famous flight. His model (Figure 140) is made 1/6 scale and is complete in every detail. When Chamberlin saw the model he was so impressed that he declared it to be the most accurate representation of the plane that he had seen. It is 7 feet, 9 inches span and was made especially for a welcoming banquet to Chamberlin held at Denison. At its conclusion Fastje gave the model to Chamberlin who greatly prizes it as a reminder of his trip. In Chapter XXIV another view of the model is shown with the pilot of the original. Other illustrations of Fastje's work appear in this Chapter.

From the Bellanca model, spanning 7 feet, 9 inches, to a model of only 1⅝ inches, is quite a reduction, but, as seen in Figure 141, Conant Emmons has bridged the gap with his miniature "Curtiss Hawk," that uses a match box for a hangar. This minute job required two weeks' work in spare hours; it has a revolving propeller, complete wing wiring, wind-shield, exhaust stacks and all markings.

CHAPTER XVIII

A MODEL OF THE "SPIRIT OF ST. LOUIS"

Having learned the method of making scale models, the reader is no doubt anxious to make a flying reproduction of some favorite type. The most popular aircraft in the world today is Colonel Lindbergh's famous partner. The following description refers to a model of this airplane that was constructed by the author for Lindbergh's Washington reception.

This is to be a flying scale model; that is, one in which the wing, fuselage, landing gear and surfaces are as nearly as possible scale reproductions of the original. In order to balance this model a small weight is added in the shape of a propeller spinner-cap and landing-gear parts. In order to avoid making the nose carry too much added weight, try and make the tail as light as possible. Some modelmakers use bamboo for the rear section of the fuselage and tail surfaces in order to obtain light construction. The reader may do so if he desires, but as this will no doubt be the first scale model for many readers, the easier steamed-wood method will be described here.

The Fuselage

The wood used for the fuselage longerons must be steamed for shaping. The steaming may be done by laying the wood in a pan of boiling water for one-half hour, or in a tube through which hot steam is passed, or by wrapping in hot, wet cloths which shall be constantly kept hot and wet for at

least a half-hour. While these sticks are steaming, start construction of the forms.

Figure 142, Sketch 1, in the drawing shows how the forms are laid out. On the 36-inch board draw a full-sized replica

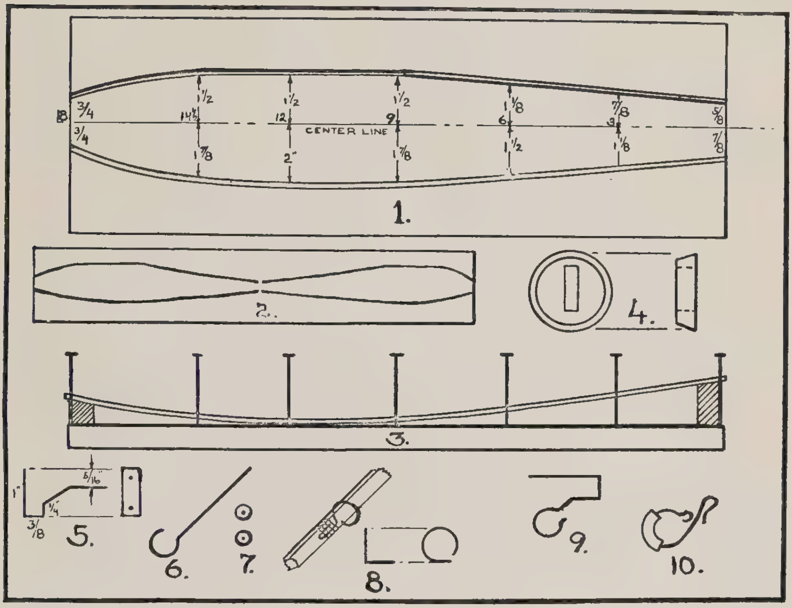


Figure 142. Fuselage Parts

of Sketch 1 and also an opposite of it. In other words, for the opposite drawing have the tail end of the drawing at the left and the nose at the right with dimensions reversed as shown in Sketch 2. At the points marked with the arrows drive in ten-penny nails. This completes the preliminary laying out of the form. When the wood has sufficiently steamed, lay one piece at a time against each row of nails, retaining them in place with other nails placed outside of the sticks. It will be necessary to bend the wood in a double curve. To do this, place blocks of wood under the ends of the sticks, and hold down the center with small staples, lightly

driven in, so as to not bruise the sticks. Sketch 3 shows how this is done, using ¾-inch blocks at the nose ends and 1½-inch blocks at the tail ends. Other blocks may be used to preserve the shape between. It will be necessary to let the wood stay in these frames overnight—24 hours would be better—so that the wood can dry thoroughly and become set in its shape.

Next make a few fittings. Sketch 4 (Figure 142) shows two views of the nose piece. It is made from a small piece of balsa wood. The ideal way to make it would be on a lathe, but it can be easily cut out with a saw and penknife, then sandpapered or filed true. Lay out a 1½-inch circle on a ½-inch piece of wood; after it is cut out and beveled, make the rectangular hole which may be carved out with a knife, or two 5/16-inch holes may be bored with their opposite edges 1 inch apart, and the intervening wood and corners cut out. Be careful not to split the wood in this process.

Sketch 5 (Figure 142) shows two views of the propeller bearing. It is to be made from a strip of flat metal 2⅞ inches. No. 16-gauge aluminum is preferred, but if unobtainable a piece of one of the beaters taken off the egg-beater described in Chapter XIII may be used. The metal is bent as shown and two No. 52 holes are bored through the front. Sketches 6 to 10 show other fittings that are to be used and made as described in Chapter VI.

After the wooden sticks which form the fuselage sides have thoroughly dried in their forms, they can be removed and assembled into a frame. Sketches 2 and 4 of Figure 143 show a number of spars of different sizes separating the longerons. Two of each of these are to be cut from sticks ⅛-inch square; then with all the requisite parts ready, the frame is assembled. To do this the two sides are first made, the spars being spaced as indicated by the figures above the center line; these denote numbers of inches from the tail.

When the sides are completed they are joined together as shown in Sketches 3 and 4 (Figure 143). Sketch 3 shows how the upper and lower spars are set in advance of the side spars to avoid weakening one spot. All of the joints are first

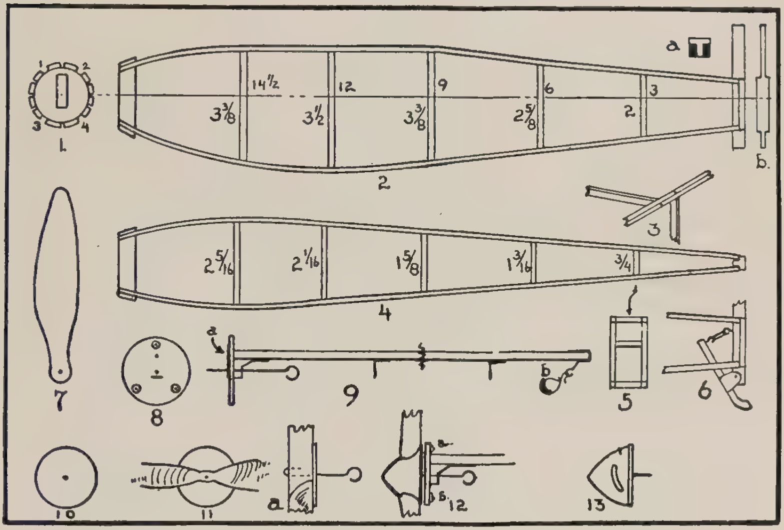


Figure 143. Fuselage Construction

touched with Ambroid and then nailed, using No. 20, ½-inch brads.

With all of the spars in place, the tail-piece is made next. It is a piece of T-section cut from a stick 3¾ inches as shown in Sketches 2-*a*, *b* (Figure 143), the latter being a rear view. The T-flanges are left on the sides for a distance of 1½ inches, at ¾ inch from the bottom end. It is nailed and glued into position and finally the nose piece is similarly fastened. Four ⅛-inch grooves are to be cut in the periphery of this piece as shown in Sketch 1 at *1, 2, 3* and *4*. They should be of such size that the longerons, or fuselage sticks, go into them flush with a tight fit.

This practically completes the fuselage, but in order to make it more nearly resemble the original, three 1/16-inch strips should be run down the length of each side and in addition short strips are run from the nose to the first upper and lower spar on top and bottom. These are to round out the fuselage; slots for these extra strips are shown in Sketch 1 (Figure 143).

The tail skid is made from a piece of wood 3/8 x 3/16 x 2½ inches to the shape shown in Figure 143, Sketch 6. A small piece of tin or aluminum sheet is bent around it and fastened with a nail for a pivot to the bottom of the tail-piece. The upper end has a nail driven through it with the projecting end bent into an eye. A similar eye is formed in a nail driven through the tail-piece, and a short rubber band is used to join the two eyes, thus giving elasticity to the tail skid to prevent breakage when the model is maneuvering on the ground.

We will next start on the power plant and the first move will be to put an extra cross-brace into the fuselage frame, 3 inches from the tail, as shown in Sketch 5. The brace is ½ inch below the top, forming a rest for the motor stick. We next make the propeller. Sketch 7 shows its blade outline. This shape is reproduced on cardboard to form a pattern. The blade is 5 inches in length, and 1¼ inches in width. With this pattern proceed with the making of a 10-inch propeller as explained in Chapter V. Paint with aluminum paint in imitation of the original standard steel propeller.

Sketch 8 of Figure 143 shows a disc of thin plywood, 1½ inches diameter, which is pierced with a slit and two holes so spaced that the bearing will be accommodated therein as shown in the side view, Sketch 9. The shaft hole must be exactly in the center of the disc. The long stick shown is 15 inches in length and 5/16 inch square. To it the bearing is fastened by a nail driven through at *a* and a binding made where the metal

strip joins the wood above the shaft-hook. The tail-hook and cans are lashed in place as shown.

Lindy's plane carried a spinner-cap mounted on the propeller to reduce head resistance. We can make one as follows: Cut a piece of cardboard into a disc 1¼ inches in diameter (Sketch 10). This is Ambroided to the hub (Sketch 11). The shaft is passed through the bearing and propeller hub and retained by bending over the projection, as at 11-*a*. The spinner-cap is formed of Plastic Wood, which is a product resembling wood but working like putty. Most hardware and paint stores carry it. From it the nose is molded as shown in Sketches 12 and 13.

For purposes of winding the motor and for making repairs, the motor stick has been made separate from the fuselage. It is attached to it now by using dress snaps. Three are spaced on the plywood disc and nose-piece, as shown in Sketches 8 and 12-*a*, *b*. They can be fastened with wire or thread passed through the holes. Dress snaps are sold at all notion stores in various sizes. The smallest should be used. One may prefer to fasten the motor stick in a wire clip as in Figure 61-*E*, mounting the clip across the nose of the fuselage.

The fuselage is to be covered with China silk or tissue paper, using dope as adhesive. Each side and the top and bottom are covered separately, using a piece of fabric slightly larger than the frame, and applying it over the longerons and spars which have previously been coated with dope. The material must be stretched tight, and after it has dried, all projecting edges must be trimmed off with a razor blade. The last section on the bottom near the tail, is left open because of the tail skid; also the top sections, second and third from the front, are left open because these spaces are covered with the wing. Fit the fabric neatly around the nose and tail post but leave no overlapping as this would interfere with the movement of other parts.

The Empennage

Four pieces comprise the tail units of this plane—the stabilizer, elevator, rudder and fin. In making the first three, it will be found an advantage if full-sized drawings of the parts are

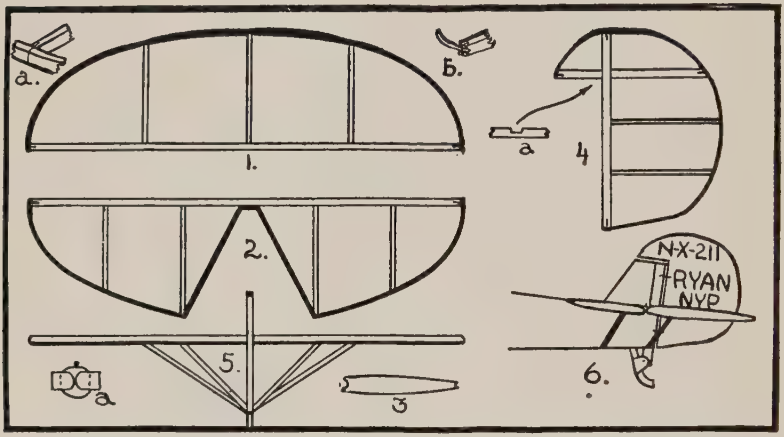


Figure 144. Empennage Construction. This should be made as light as possible to avoid tail-heaviness in the finished model

prepared, over which the pieces of wood are fitted and assembled. This method insures good joints and well-shaped pieces. The stabilizer is shown in Figure 144, Sketch 1. It is made out of a spar, three ribs and an outline piece. The spar is 8 ½ inches in length by ⅛ inch square. The center rib is 2 ¼ inches in length and shaped as shown in Sketch 3. The ribs are glued or Ambroided in place and may be wired as shown in Sketch 1-*a*. The other two ribs are of similar shape but a trifle shorter in order to conform to the outline piece which is made from 1/16-inch square bamboo, heated over a candle flame, curved and bent to shape, as was done for similar parts described in previous chapters. The outline piece is fastened to

the spar by making a "V" cut in the end of the spar and Ambroiding and wiring the bamboo therein (Sketch 1-*b*).

In some models the elevators are made in two pieces, but in this one we will join them together as in Sketch 2. The dimensions and construction are similar to the stabilizer, making the bamboo outline like a "W" with the cross-bar in the center ⅜ inch in length.

The rudder is made according to the drawing, Sketch 4 of Figure 144. The upright backbone is 4 inches in length by ⅛ inch square. The upper cross-bar is 3 inches in length by ⅛ inch square. Three-quarters of an inch from the end of each, they are joined by a halved-together joint. The outline piece is shaped from 1/16-inch square bamboo and fastened to the pieces as at Sketch 1-*a*. Two ribs similar in shape to Sketch 3 are Ambroided in place as shown. Before applying the fabric, the spars and the rudder backbone are to have their edges rounded in order that they may hinge easily, as shown in Sketch 5-*a*. These three surfaces are now to be covered and then doped.

In order to duplicate the appearance of the original, these surfaces are now to be painted with aluminum paint. The rudder is lettered as shown in Sketch 6. It will be observed that the letters have curved sides, as in the original. The "NYP" stands for "New York to Paris."

These surfaces are to be fastened with wire to the fuselage, at intersecting points; Sketches 5 and 6 show how this is to be done. The stabilizer and elevator are hinged together, as in Sketch 5-*a*, with a piece of wire passed through holes in the spars and twisted tightly so that the surfaces may be moved but not be loose. Then double braces are to be Ambroided in place, as shown in Sketches 5 and 6. The rudder is hinged to the tail-piece. The fin consists of a piece of cardboard or thin wood cut and Ambroided in place, as shown in Sketch 6.

The Wing

The wing requires the following wood:

1 balsa entering edge, 32-1/2 x 3/8 x 1/4 in.
1 pine spar, 32-1/2 x 1/4 x 1/8 in.
1 balsa trailing edge, 32-1/2 x 1/8 x 1/16 in.
17 ribs made as described below.
2 balsa strengtheners, 4 x 1/2 x 1/4 in.

If ailerons are added use the following:

2 pine inserts, 4-1/2 x 3/8 x 1/16 in.
2 pieces balsa, 4-1/4 x 1/4 in. square
1 balsa slat, 7 x 1/2 x 1/16 in.
Bamboo

The ribs are made in the following manner. The designers of the "Spirit of St. Louis" adopted a wing section known as

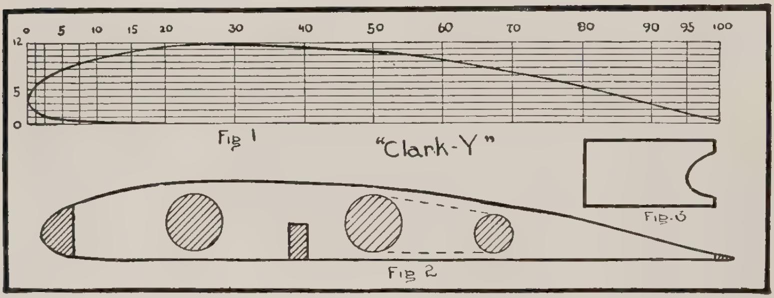


Figure 145. Wing Rib

the "Clark Y," because it imparts to an aircraft the two desired properties of speed and lift. In Chapter XIX the drawing of a wing section from ordinates is explained. Using that method, a graph 5½ inches in length is made as shown in Figure 145, Sketch 1. The table below shows at what points on the vertical lines marks are made to indicate the intersection of the upper

and lower surfaces. When these marks are joined, the Clark-Y outline will result, as shown in Sketch 1.

Vertical Line	Upper Surface	Lower Surface
0	3.5	3.5
1.25	5.45	1.93
2.5	6.5	1.466
5	7.9	.933
7.5	8.85	.629
10	9.6	.42
15	10.685	.15
20	11.36	.033
30	11.7	.0
40	11.4	.0
50	10.515	.0
60	9.148	.0
70	7.35	.0
80	5.216	.0
90	2.802	.0
95	1.494	.0
100	0.12	.0

The piece of paper upon which this section has been drawn is now to be pasted on a piece of tin and the outline cut out, making a pattern. Cut off the nose of this pattern ¼ inch from the front, and the tail ⅛ inch from the rear, eliminating the shaded portions in Sketch 2 of Figure 145. Cut out the ⅛ x ¼ inch opening in the bottom 2 inches from the original front. Now from 17 slats of balsa wood, 5⅛ x ¾ x 1/16 inches, the ribs are to be made. On 15 of these trace the pattern and cut out the shape. The other two slats are to be cut to the original outline. The two rear shaded holes are to be joined as shown by the dotted lines to further eliminate weight.

Sketch 3 shows a piece of tin or other metal which has one end ground out to the shape of the nose of the rib shown shaded in Sketch 2. This is to be used in shaping the entering edge of the wing, which is first roughly planed to the section

shown at the nose of Figure 145, Sketch 2, then finished with the scraper in Sketch 3. On the back of this edge, starting at the center and at each outward point 2¼ inches away, saw-cuts are to be made 1/16 inch in width and depth; the spar is

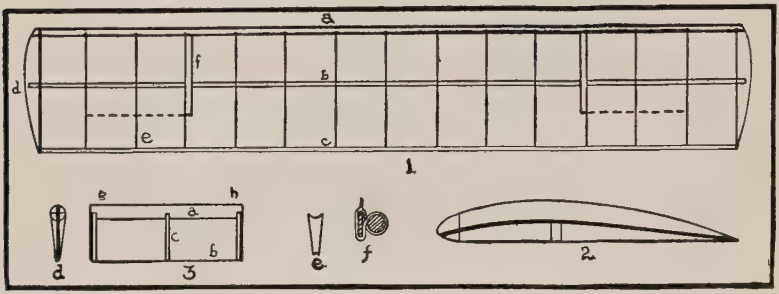


Figure 146. Wing Construction

then painted with banana oil to strengthen it. While it is drying, the ribs are Ambroided on the pine spar (Figure 146, Sketch 1-*b*) 2 ½ inches apart outward from the center, care being taken to see that all are in line and true. Each rib is now to be Ambroided in its corresponding niche in the balsa entering edge. The trailing edge *c* is Ambroided to the rear of each rib, as in the same illustration and in Figure 145, Sketch 2.

In Figure 146, Sketches 1-*d* and 2 show how the ends are made. The two whole ribs are slightly curved by holding them either in the heat of a candle flame or a steam flow, for bending. After cooling in this position they will be permanently set and are to be fastened with Ambroid as shown. If desired, this joint may be made stronger by using a few small pins pushed through from the upright rib into the end rib. Two 1/16-inch holes are now drilled 1¼ inches from the center in the spar for attaching the wing to the fuselage. The balsa strengtheners, mentioned in the list of material, are cut in the

bottom to admit the spar, and Ambroided inside the fourth rib from each end, as shown at 1-*f*.

The wing frame is now complete, unless it is desired to fit ailerons. On this type of airplane they are set in the trailing edge a short distance from the wing tip by first cutting the rib *e* (Figure 146, Sketch 1) and the corresponding one at the opposite end, at a point 1½ inches from the rear. Where the dotted line indicates, Ambroid the pine inserts. Next, take the two short balsa pieces, mentioned in the bill of material, and plane them round.

Make little nicks in the ends of each for the insertion of the outline piece (Sketch 3-*b* of Figure 146) which is to be made U-shaped from 1/16 inch square bamboo and Ambroided in place. Make six ribs, cutting them to the shape shown at Sketch 3-*c* and *e,* 1⅛ inches in length, using the balsa slat as material. Ambroid these in place. These ailerons are now covered and are fastened to the wing frame by passing a pair of wires around the balsa spar in each at *g* and *h*, crossing the ends and carrying them around the pine insert in the frame, as shown at *f*.

The wing is now covered with a piece of fabric 34 x 12 inches; coat the entering edge with dope and insert it into the longitudinal center of the cloth, rubbing over the edge to adhere the fabric. Next carry the cloth over the top to the rear edge and similarly dope it along this. Pull the cloth tight out to the ends and fasten it there, after which all excess fabric, except the large flap at the front, is to be cut off. Next, cover the bottom in a similar manner, and then when all adhesive has dried, dope the wing, coating the bottom side first. The dope will make the fabric adhere to the ribs and other pieces. It is obvious that the space occupied by the ailerons was not covered. The completed wing should now be fastened to the fuselage. This is done by means of two small screws No.

00, ½ inch, passing through the holes near the center of the wing and into the second upper spar of the fuselage. Be sure that the wing is at right angles to the center line of the fuselage. Wire the trailing edge to the top longerons.

The Chassis

The following material will be required for chassis construction:

4 pine braces, 9 x 3/4 x 1/8 in.
2 pieces metal tubing, 4-3/4 in. in length with a 1/8 in. inside diameter.
2 pieces of the same tubing, 5-1/2 in. in length.
1 piece of the same tubing, 3-3/4 in. in length.
1 piece balsa wood, 4-1/4 x 3/8 x 3/4 in.
2 upper pine braces, 3 x 1/8 in. in diameter.
2 lower pine braces, 4 x 1/8 in. in diameter.

Prepare the four braces which reach from the bottom longeron to the wing strengtheners, as shown in Figure 147, Sketches 1 and 2. At a distance of 6 inches from one end, the front two of these are to be cut over to one side and this remaining part rounded, as shown in Sketch 2-*a*. The flat section of the braces is to be streamlined—that is, made so it will pass easily through the air—to the shape shown in Sketch 5-*a*. The rounded part goes in front. Now take the two 4¾-inch lengths of tubing and pinch a portion near one end as shown in Sketch 3, and through this part drill a hole large enough to pass a small screw, No. 00, ¼ inch, with a round head. The long portions are 4 inches in length and the bends are such that when the long parts are placed at a 45 degree angle, the sockets will engage the long wing braces.

These tubes are to be screwed to the fuselage, as at Sketch 2-*c*, and the streamlined braces fastened in the short sockets

with their other end nailed to the strengthening pieces in the wing. The two 5½-inch tubes are shaped and attached in like manner, but must be bent forward from the pinched portion to meet the lower end of the front tubes, as shown in Sketch 2-*g*. The rear wing braces, *b* are streamlined throughout their length except the bottom end, which is rounded to fit the tube. The

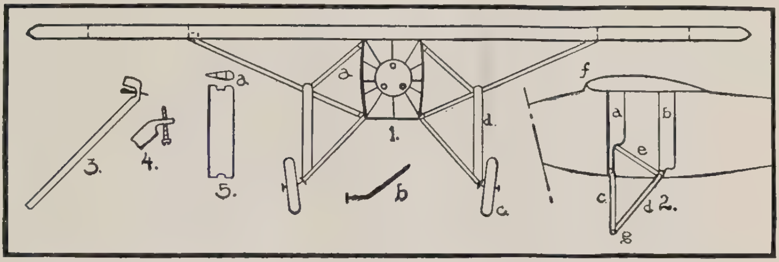


Figure 147. Chassis

braces are fastened in the tubes with Ambroid and retained by a small nail driven in a hole drilled through the socket.

Obtain two wheels about 2 inches in diameter. (See Chapter XV.) Now take two nails about No. 16, 2 inches in length, pass them through the wheel axles and bend them as shown in Sketch 1-*b*. Solder a small washer on the nail near the wheel, pass the shank of the nail up the front tube, and solder the nails and two tubes together, as shown in Sketches 1-*c* and 2-*g*. Two upright braces are next made. They are shaped as shown in Sketches 1-*d* and 5, from the piece of balsa wood 4¼ inches in length; they are Ambroided and wired at the two points of intersection. From the short length of tubing, six tube sockets are made as shown in Sketch 4. Two of these are used to attach the upper end of the upper braces (Sketch 1-*d*), the lower end being wired to the juncture. The other four are used on each end of the two braces (Sketch 2-*e*) which extend from the point of juncture just named to the

(Erickson Photo)

Figure 148. The "Spirit of St. Louis" in Flight

joint of the rear brace and longeron. The rear socket is fastened under the other socket, using the same screw for both.

In the original plane flown by Lindbergh, every effort was made to reduce head resistance. One instance was in the joint between the wing and fuselage, where the two were blended together. We will do the same thing and attach a piece of covering to the upper surface of the fuselage in front of the wing, as shown at Sketch *2-f,* carrying it over the wing, and fasten it in back of the trailing edge. Dope may be used for adhesive; care must be taken to get a smooth joint.

Completion and Flying

The model which you have so nearly completed should be a very close reproduction of the original "Spirit of St. Louis," but differs from it in a few details. The most striking departure is the propeller which we have had to increase in order to make the model capable of flight. The original size propeller scaled down would be inadequate. To accommodate the larger propeller, we have lengthened the landing gear, and braced it a trifle differently to allow for its increased length. In the original plane, the upright streamlined braces are enclosures for the shock absorbers, but we have not added this detail. Lindy's plane had the juncture of the slanting streamlined braces and the wing enclosed in a housing. This may be duplicated by forming the housing from Plastic Wood.

Much can be done in the way of improving the model by painting it. All surfaces should be covered with aluminum paint. On the right under side and the left upper side of the wing, facing the model, the designating mark N-X-211, Lindy's license number, is to be painted with large letters in paint facing rearward.

You should look through back issues of magazines and newspapers and find a photograph of the original plane and

from it copy other features. In this way you will see a window on each side through which Lindbergh observed the progress of his plane; also a set of six small windows are in the wing above the others. These windows may be indicated by black paint or by cutting the fabric and inserting a piece of celluloid in the proper place. All of us recall the beautiful metal nose of the original. You may duplicate this by covering it with tin foil which has a mottled figure pressed into it, such as comes around some cigars, candy, and typewriter ribbons. Fasten it on with shellac. The lettering "Spirit of St. Louis" should be added to the nose.

An imitation *Whirlwind* engine can be made of dowel sticks from which flanged cylinders are turned in a lathe and then Ambroided to the nose; there are nine arranged radially. The exhaust stacks and inlet manifold can be formed from tubing and the tappet rods may be represented by toothpicks; all fittings should be Ambroided in place. The earth inductor compass, gasoline vents, air-speed indicator, etc., can be copied from photographs (see Figure 148 and the illustration on page 8), being fashioned from bits of wood or metal.

To fly the model, set all controls in neutral. Remove the motor stick and attach to it twelve strands of rubber looped from a piece 15 feet in length. It is hung at the rear with the S-hook. Wind the propeller about one hundred times. Insert the motor in the model, clip the dress snaps to retain it, and rest the model on the ground having it on a smooth runway facing a clear area for at least 200 feet ahead; then release the propeller. The model should rise from the ground and fly. If it is off balance, correct with the controls or by adding a slight weight to the nose inside the fuselage. By manipulation of the controls the model can be made to perform various maneuvers.

CHAPTER XIX

DESIGN AND METHODS

The reader who has followed the author through the book thus far has learned how to make many models in many different ways. There are numerous designs of models in existence, and the future will bring out new and unique types, some of which no doubt will establish records and perhaps change the present trend of construction. It is the purpose of this chapter to explain a few of the structural principles with suggestions for other methods of construction so that the reader may be able to design and build original models.

In considering any model there are four main components; these are, the supporting surface, control surface, body and source of power.

Supporting Surface. The first wings used on models were flat, but when men studied the birds more closely they found that nature's wings were curved; when they followed her example their flight results improved. On single surface wings the lift is due to the vertical reaction when the air in motion strikes the inclined surface, the same as with a kite. The modern wing, however, is double-surfaced, and derives its lift not only from the lower side but also from the upper; in fact the lift is more to be credited to the suction effect from the upper surface.

At Figure 149, Sketch *A*, a double-surfaced wing is shown. It is obvious that as the wing moves forward the air will be parted at the front and rejoined behind the rear. Naturally the air that passes the bottom surface will travel a shorter distance

than that which goes over the top; therefore, in order to arrive at the rear at the same time, the upper air must move faster. This stretching out makes the air less dense, resulting in a partial vacuum. Thus it is that the wing is not only pushed

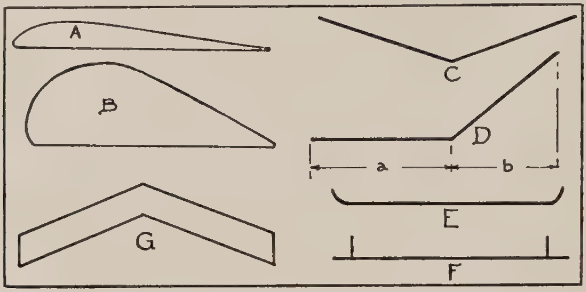


Figure 149. Wing Theory

from the bottom but it is also sucked up at the top. The inference may be that if this suction is dependent on the greater distance the air travels in going over the top surface, why not make the wing very rounded as at Sketch *B*. The reason for not making "watermelon" wings is that the lift alone does not decide the performance of a wing but the lift in relation to the resistance (drag). Such a wing as that at *B* presents so much resistance that it cannot move at sufficient speed to generate a lift. The nose shape and angle of attack also affect the lift.

The whole science of wing design is a compromise between lift, resistance, and balance. Experiments with wing shapes have resulted in the development of many forms, some suitable for speed, others for weight-carrying, or for fast climb. The results of these experiments are available to designers and are often used by modelmakers in perfecting their craft. The National Advisory Committee for Aeronautics, Washington, D.C., has prepared data and drawings on several hundred different wing shapes. Their Reports show the wing outline,

its performance at various angles and how it can be reproduced.

Figure 150 shows such an outline, this particular wing-shape being the section used on many successful airplanes,—most notably on the Douglas cruisers that flew around the world in 1924. It is called the U. S. A.-27. To reconstruct this shape, accurately, first prepare the graph. This is as long as the chord (or width) of the wing. Divide the length into ten parts, and with the dividers still set for one-tenth of the

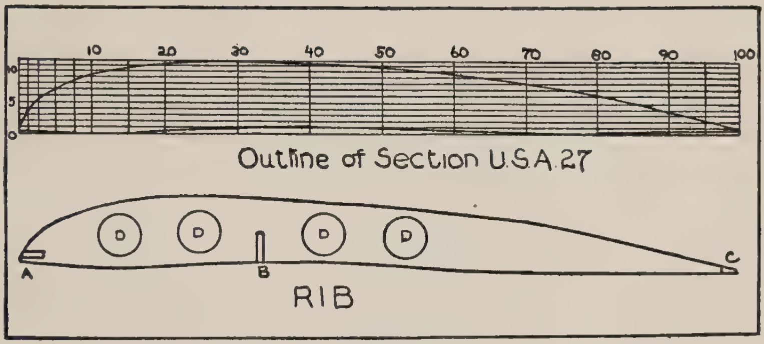


Figure 150

chord, extend this same distance below the line and divide it into ten parts. Draw horizontal lines across from each of the one-tenth subdivisions at the left, also vertical lines downward from the chord subdivisions. Draw extra lines into the first section, at positions 1¼, 2½, 5 and 7½; number the other lines 10, 15, 20, 30 and so on; in the last section inserting 95 and finally 100. Add two horizontal lines below the tenth and number all twelve from 0 to 12 upward from the bottom. This completes the graph. The drawing shows how the wing-shape intersects the graph lines.

The following table refers to these points of intersection. Its units are given in fractions, buc in the published scientific reports decimals are used.

Vertical Line	Upper Surface	Lower Surface
0	1-4/5	1-4/5
1-1/4	3-4/5	1/2
2-1/2	5-1/10	1/3
5	7	1/5
7-1/2	8-1/5	1/10
10	9-1/5	0
20	11-1/3	1/3
30	12	1
40	11-1/2	1-1/5
50	10-4/5	4/5
60	9-1/2	1/4
70	8	1/10
80	6	1/20
90	3-3/5	1/5
95	2	1/2
100	3/5	3/5

Connect the various marks you have made and the result will be a drawing to the proper wing chord of the U. S. A.-27 wing section. This shape is very good for models. The Reports referred to contain many more sections from which you can choose those embodying the qualities that are desired, and by the graph method adapt them to your models.

In regard to the rectangular plan shape of the wing, this feature is known as "aspect ratio" and is the relation between the span and chord. An aspect ratio of seven is considered good, for example, a span of 35 inches and chord of 5 inches. Within certain limits, the higher the ratio the greater the speed, the limit being about 15 for models. The low limit would be around 4.

In regard to balance or stability, it is necessary that this be built into models as they have no guiding intelligence aboard. The best method is the use of the dihedral angle, which slopes upward from the center. Figure 149, Sketch *C,* shows in an exaggerated way how it appears from the front, and *D* explains

its action. When raised on one side by a wind disturbance, the lift immediately becomes greater on the down-pressed wing and less on the raised one as is evident by a comparison of *a* and *b*. The result is a force tending to return the wing to normal. Too much dihedral results in loss of lift and causes rolling, therefore use it sparingly: a raise of 2 inches at the tips of a 36-inch wing is about right.

Some models employ upturned wing ends for stability (Sketch *E*). The effect of these is that a slanted wing tends to slip, but when it starts to "slide down," the upturned ends cause the lower end to level off. Small keel surfaces near the wing ends as at *F* are also useful; they prevent skidding.

The fore-and-aft stability of a model is also important. This is accomplished in some machines by "sweepback" of the wings as at *G*. Such a shape closely follows the air stream that is parted by the nose of the model. Excessive sweepback as at *G* is seldom used on a model unless it is of the Dunne type, which has a sweepback of 30 degrees and is so longitudinally stable that it requires no tail surface. Longitudinal stability is also maintained by having the wings set at different angles to the air stream. If a model tends to pitch violently, raising the rear edge of the wing by a small block may correct it. Another important feature in pusher models is to have the wings far enough apart. About four times the chord of the wing is correct. The parts of the model should be so grouped that the center of gravity is not too high. Preferably it should be even with, or slightly below, the centers of thrust and pressure.

Biplanes and triplanes are interesting to build as models. Their advantage is that wings of high aspect ratio can be used and that the necessary trussing increases the strength of the whole. Their disadvantage is the increased resistance due to the various struts, wires and fittings; also the difficulty of constructing biplanes as compared with monoplanes. The

distance between the wings known as the "gap" should never be less than the chord, preferably about the same. For stability, the wings of a biplane should be set at slightly different angles to the air stream (this is known as decalage) the greater inclination being on the bottom wing. Advancing the top wing ahead of the lower one (stagger) increases the lift of the front end of the model.

Control Surfaces. Control surfaces include elevators, stabilizers, rudders, keels and ailerons. By their use a model is balanced and controlled. Previous chapters have illustrated their use and little remains to be said of them except that the farther they are placed from the center, the greater will be their leverage; rudders are more efficient at the back than in the front, and underneath than on top. Generally the stabilizer and elevators on a tractor should not have a lifting section as that tends to make the model pitch. The size of the control surfaces should vary approximately with size of main supporting wings.

Fuselages. Model aircraft fuselages are intended for easy passage through the air and for strength with lightness. To

Figure 151. The Flow of Air Around a Square Object

that end all square corners should be rounded and smoothed with sandpaper. All parts exposed to the action of the wind should be streamlined, that is, shaped like the outline of Figure 151. There is shown a square object immersed in an air stream. The air strikes and flows around it, turning off abruptly at the front and gradually joining together at the rear, but leaving a turbulence in rear of the object. This disturbed

area is a great drag on the speed of the model. Thus it is seen that exposed parts which have that fish-shaped outline conform to the air stream and do not disturb the air so much. An object as large as the outline has less air resistance than the smaller square, with the greater opportunity for strength.

To reduce head resistance, some models have been made with the rubbers enclosed in a hollow motor stick, about ¾ inch square made from thin strips about 36 x ¾ x 1/16 inch balsa, Ambroided together at the edges and wrapped about every 3 inches with silk thread, the whole being finally doped. Such a motor stick is extremely strong and light.

Power. Propeller construction has been thoroughly dealt with in Chapter V. As to their shape, thin blades are best for speed and wide ones for duration. Tapering the original blank before cutting, results in a propeller capable of more speed. The correct combination of propellers and models is largely a matter of trial. Their diameter may be from ⅓ to 1/5 of the wing span. The writer prefers to glide a completed model and decide upon the type of propeller after ascertaining the speed and behavior of the model in the air. If it tends to fly fast, thin-tapered blades are used, if slow, wide blades are appropriate.

The thrust of propellers is measured by their pitch which is of two kinds, geometrical and actual. The geometrical pitch is the distance the blades would advance in one revolution if operating in a solid substance, but because air is not solid, there is some loss called "slip." The actual pitch is the geometrical, minus slip. Geometrical pitch is determined by the formula:

$$\frac{D \times \pi \times Th}{W}$$

where D is the diameter, π is the number 3.1416, Th is thickness of the blank, and W width of the blank. A 10 x 1 x ¾ inch

blank would result in a propeller having a pitch of 23.6 inches. Allowing 25 per cent for slip, the actual pitch of such a propeller would be about 19 inches. If it rotated 600 times a minute its advance would be about 950 feet per minute; 11 miles an hour; therefore, at that speed it could be used for a

Figure 152. A Duration Model (237 seconds, 4,457 feet, 1½ ounces) Made by Christy MacGrath

medium speed model. If a model refuses to fly with its present propellers, they should be reduced in diameter or pitch, resulting in more thrust and possibly making the difference between success and failure for the model. Adding rubber often helps.

Thus we can conclude that a speed model should have thin taper-bladed medium-pitch propellers, wings of high aspect ratio, with a section that not only is convex on the top, but also slightly so on the bottom. For speed sections see the National Advisory Committee Reports referred to previously. The frame should be streamlined at every exposed point, smoothly sandpapered, and strong enough to stand the strain of powerful rubbers tightly wound, for it is many strands tightly strung which give speediest revolutions. For very fast models, the

thrust could be increased by adding more propellers, for instance, making a rectangular fuselage with propellers at each corner.

Duration requires wide thick wings, slow-turning high-pitch propellers, driven by few strands of rubber. Such models

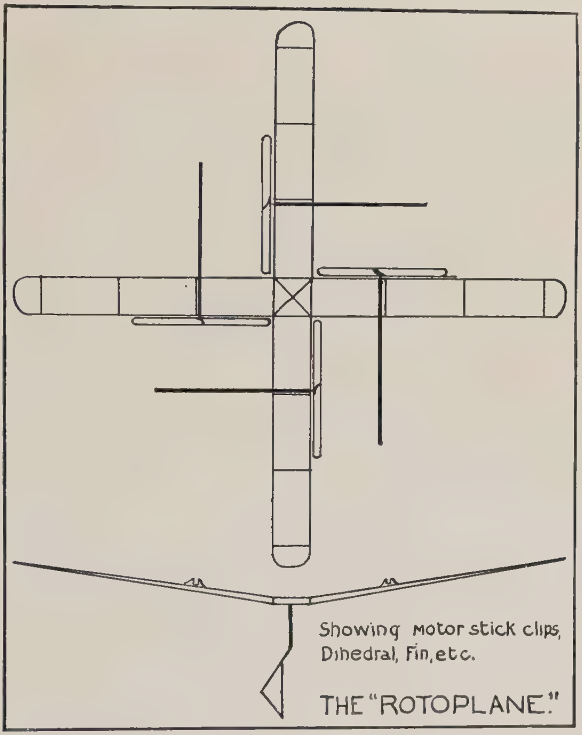


Figure 153

must be built extremely light so that the slow-turning propellers and slow-moving wings can lift the weight. Such construction cannot undergo the strains of high speed.

Some modelmakers may desire to enter the two rather slightly unexplored realms of model aircraft classed as ornithopters and helicopters. The former are wing flapping ma-

chines. A few successful ornithopter models have been made in the past, notably by Pichancourt of France in 1889, and Hargrave of Australia, in 1891. (See Figures 183, 184.) The former used rubber strands for power, the latter employed compressed air. However, they serve more to amuse than to instruct, for the beating wing is not as efficient as the rotating propeller for man-made aircraft.

The flying tops described in Chapter II are elementary helicopters, or vertically ascending aircraft. Larger, rubber-powered helicopters can be made by mounting the motor sticks upright and adding suitable bracing with plenty of keel surface to keep the device from rotating from the torque of the propeller. Figure 153 shows a type of helicopter in which the wings are in reality propeller blades and are revolved by the pull of small propellers mounted on their entering edges. For its description the author is indebted to Nathan L. Mallison, Superintendent of Recreation at Knoxville, Tenn., who names it a "rotoplane" because the whole machine rotates, screwing its way upward through the air. The center piece is a box made of balsa wood slats, 3 x ½ x 1/16 inches, cross-braced with wires. Four wings are constructed, having a span of 20 inches and chord of 3 inches. They are lashed to the center box, with their front edge on top and the rear edge on the bottom. Wire clips, similar to those shown in Figure 61-*E*, are lashed to the wings and into them the motor sticks are fastened. Four 10-inch propellers are attached to 12-inch motor sticks on which are strung from two to four strands of ⅛-inch flat rubber. A fin may be added for stability.

The weight of flying models is a very important factor in determining their flying ability. The less a model weighs the fewer strands of rubber are required to power it, and the fewer the strands, the more revolutions may be stored in them. Flying scale-models vary from 3 to 8 ounces; the best outdoor twin-pushers weigh about 1½ ounces; the best indoor tractors weigh about ¼ ounce.

CHAPTER XX

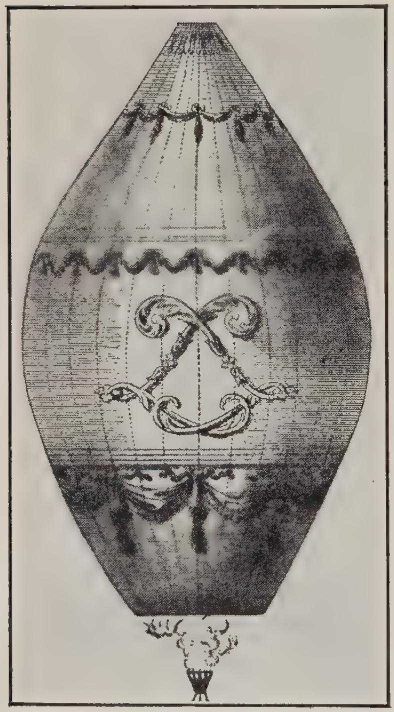
MODEL BALLOONS

The making of model balloons is an interesting and instructive pastime; the air voyages made by them are productive of increased knowledge of the winds, and in following this sport the devotee is repeating an experiment which, a hundred and fifty years ago, would have made him famous, for it was with a balloon similar to that about to be described that the Montgolfier Brothers who lived in the town of Annonay, France, made history, on June 5, 1783.

There is an amusing legend accounting for the way in which Joseph and Stephen Montgolfier became interested in ballooning. It is told that when youngsters they were helping their mother dry some clothes, and made a small fire under a dress to hasten the drying. All of us know that hot air is lighter than cold air; in winter when our homes are heated we can raise our hands and feel the warm air near the ceiling, then lower our hands and notice the cold air near the floor; so it was that the hot air inflated the dress, and in tending to rise, carried the dress off the line and floated it several feet away before the air cooled and the dress fell. Incidentally, a good joke would be lost if no mention were made of the fact that it is lucky for the science of ballooning that the Montgolfiers lived in their day rather than in these times, for a modern skirt would hardly do for such an experiment.

At any rate the boys were interested by the skirt's behavior and immediately sought to repeat the experiment with paper bags, but they experienced some difficulty owing to leaks which

permitted the hot air to escape. They tried other vapors such as steam, smoke and hydrogen but finally returned to hot air and to contain it made a small paper balloon. This caught fire when inflation was tried, but they built another, inflated it successfully and it rose over 1,000 feet. Thus encouraged they built out of paper the balloon shown in Figure 154, which was readily procured as their father was the owner of a large paper mill. The balloon was 35 feet in diameter. It was hung from a rope stretched between two poles; they built a fire under it to inflate it with hot air; when released it ascended about a thousand feet and stayed in the air ten minutes. This occurred June 5, 1783, and was the first public exhibition of the balloon. Subsequently the brothers were invited to repeat their experiment before the Academie des Sciences in Paris which they did successfully; they were decorated by their King and lived to make many improvements in the invention.



(Courtesy: U. S. N. M.)
Figure 154. Montgolfier's Balloon

Since those days the balloon has developed into the beautiful object of today, and many readers can find much to interest them in the making of a small Montgolfiere, as such balloons are often called. Through the courtesy of Mr. Mallison, Director of Recreation for Knoxville, Tennessee, the author

is able to give a description of the methods which proved successful in that southern city. The following material is necessary for making a paper balloon:

1 roll (ten yards) of tissue paper, 1 yd. wide
1 piece stiff wire, 5 ft. in length
2 pieces smaller wire, each 20 in. in length
Paste or mucilage
1 piece of oil-soaked rag or waste

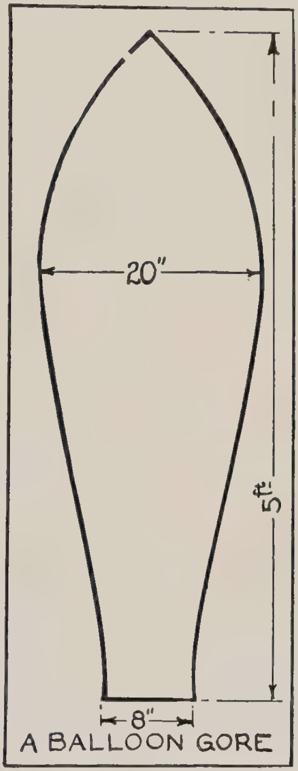


Figure 155

Make a leaf-shaped pattern by cutting from newspaper a shape having the dimensions shown in Figure 155. Unroll the tissue paper and lay the pattern on it, drawing around it with a pencil. By careful use of the tissue paper you will be able to get eight pieces from it. Now overlap one pattern, 1½ inches upon the edge of the other, and paste down. Do this successively for each gore, finally pasting the eighth gore onto the first one and completing the barrel-like shape. Let the paste dry, then spread out the open bottom of the balloon, ascertain its circumference and make a ring from the 5-foot length of wire to fit it. Put this 1 inch from the bottom, fold the paper over it and paste down. Fasten the two smaller wires across this ring like an "X." This completes the balloon.

To launch it, choose a nice, clear day, and select an open field away from buildings. Take a piece of oil-soaked waste or rag, fasten it to the center of the cross-wires, hold the balloon

Figure 156. Launching the "Pride of South Knoxville" at a Contest Held at Knoxville, Tennessee, July 4, 1927

vertical, opening up its folds, and light the waste, being careful to keep the paper from catching fire. Soon you will notice the balloon swelling out as the air within becomes heated and

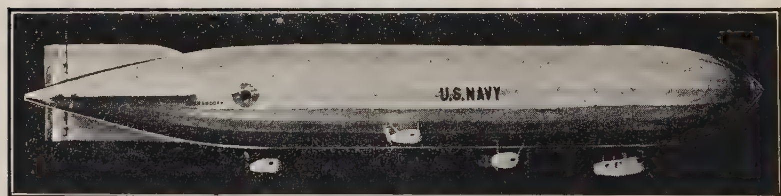


Figure 157. A "Shenandoah" Model Made by "Bud" Irelan

expands; shortly thereafter when released, it will ascend into the air as did the Pride of Knoxville" shown in Figure 156.

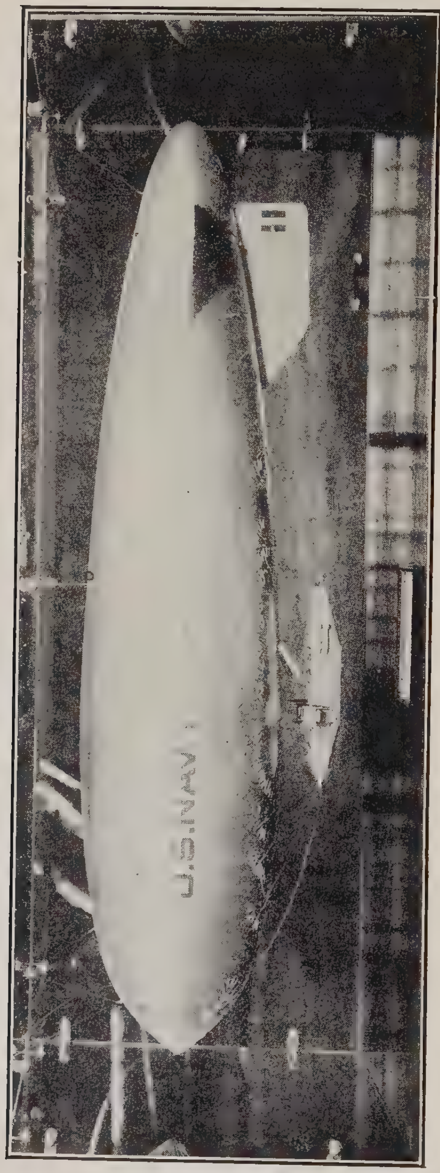
The balloon will remain in the air as long as the air in it continues heated. Its altitude will depend upon the capacity, degree of heat, and weight; therefore by providing an adequate heating unit and taking care with the construction, aerial voyages of considerable length can be made by these balloons. It is fun to attach a self-addressed postal card to a balloon for

the finder to mail back to you. Its postmark will show when and where the balloon was found. Care must be taken in launching the balloon that it does not strike against inflammable objects, such as buildings, when it rises. If it is well made it will stay aloft until the waste burns out, consequently there is no danger of fire when it lands.

The reader may become so enthused over his success with these hot air balloons that he will want to make better ones and fill them with hydrogen, but this is an expensive undertaking. Hydrogen gas requires chemical equipment for its manufacture; also the balloon to contain it must be leak-proof, yet light. About 15 cubic feet of hydrogen is required to lift one pound, consequently if too much weight is required for leak-proofing, the bag will be too heavy to rise. The U. S. Weather Bureau, Signal Corps, the Navy, and the Air Corps use small hydrogen inflated ballons for testing the extent and variation of air currents. The balloons are made of rubber and are inflated by hydrogen stored in a tank.

The reader who wishes to pursue the making of aerostats still further probably will be interested in the construction of a small-scale model of a dirigible balloon. Figure 157 shows such a model. Its framework is made of rings of reed and strips of wood. The reed is made into circles by boiling until soft (about ½ hour) and then laying lengths of it around a circle of nails, holding it in place by other nails until it is dry (about 24 hours). There are 20 circles in this model, and although most are of the same size, smaller ones are used in the bow and stern. They are held apart by long strips of thin wood which are bent at each end by softening with hot water and laying them in a nail-form until dry. After this treatment they retain the shape. The strips, 24 in number, are wired to the inside of the circles.

Before the frame is covered, the placement of the tail sur-



(Courtesy: U. S. N. M.)

Figure 158. A Beautiful Airship Model Made by Modelmakers of the Navy Department

faces and cars or gondolas is decided upon, and the frame is reinforced at these places with little pieces of balsa wood which are to receive the parts named. The frame is now covered, using China silk fastened with adhesive to the strips and carefully cut and fitted to the ends. The tail surfaces are cut from thin planks of wood and fastened to the balsa blocks within the frame by Ambroid and nails. The nails are small, with their heads cut off, and are pushed half-way into the tail-piece, then into the model frame, thus bringing them together.

The gondolas are cut from small blocks of wood, painted to resemble the originals, fitted with little windows cut from the transparent paper which comes on candy boxes. Small propellers are whittled out and fastened to each power-egg. The power-eggs and control cabin are fastened in place with struts made of wire or wood, Ambroided in snug holes in the gondolas and frame. The bag and gondolas are painted with aluminum paint to resemble the original and the lettering, name, cocardes, rudder stripes, etc., are painted on the hull.

The model shown is 3 feet in length with a largest diameter of 6 inches. Its maker obtained the specifications by scaling them down from a series of photographs of the original.

Figure 158 shows a beautifully made model of a non-rigid type of dirigible balloon. This model is in the National Museum at Washington, and is about 4 feet in length. Of course, models such as those illustrated are too small to hold enough gas to raise them, but they are interesting to make, combining educational and decorative features when finished.

CHAPTER XXI

HOW TO MAKE A COMPRESSED-AIR ENGINE

The modelmaker who wishes to power his models with a more dynamic source of motion than rubber bands, has quite a number of energies from which to choose. Besides the familiar rubber bands, models have been made to operate with springs, compressed air, gasoline, steam, carbon dioxide and electricity. At the first National Tournament held by the Playground and Recreation Association of America, Wm. E. Atwood was the only one to enter the contest for models powered with other energy than rubber. He used a spring motor from an alarm clock, with the escapement and unnecessary parts cut out. The model flew about 20 feet and captured the prize. It is certain, however, that as modelmaking becomes more familiar, more and more dynamic engines will appear. Small gasoline engines can be made by any energetic boy, and have been used for flying models. Plans for them are frequently published in modelmaking magazines, and castings for their parts are procurable from model supply houses that advertise therein.

Small steam engines were used by Langley in his first successful models. He used flash steam and a compound cylinder. Many modern models, particularly in England, employ steam engines. Plans for them and for carbon dioxide engines are frequently found in issues of English model engineering magazines. In the National Tournaments conducted by the P. R. A. A., limitations of size are put upon all models competing. The limit of 48 inches would hardly permit the use of gasoline,

steam, or carbon dioxide. Electricity, because it requires the addition of batteries, is too heavy for most flying models, and its use is generally confined to exhibition models. Thus, through a process of elimination, compressed air is arrived at as the most practicable form of dynamic energy for models other than twisted rubber.

Several years ago when the writer made his first compressed-air engine, he studied several sets of plans and decided upon those in the book, "Model Aeroplanes and Their Motors," by George A. Cavanaugh, as being the simplest and requiring the least machine work. This book is now out of print and its publishers are no longer in business. Consequently, in order to make these plans available they are reprinted below; the author has copied the drawings. Mr. Cavanaugh's article follows:

"To make a simple two-cylinder opposed compressed-air power plant, as illustrated in Figure 159, it is not necessary that the builder be in possession of a machine shop. A file, drill, small gas blow-torch and a small vise comprise the principal tools for the making of the motor.

"The first things needed in the making of this motor are cylinders. For the making of the cylinders two fishing rod ferrules, known as female ferrules, are required and for the heads of the cylinders, two male ferrules are required. Such ferrules can be secured at most any sporting goods store. The female ferrules should be filed down to a length of 2 inches, cut down on one side a distance of ¾ of the diameter, then cut in from the end, as shown at *h*. When this has been done the two male ferrules should be cut off a distance of ⅛ inch from the top, as shown at *i*, to serve as heads for the cylinders. A hole of ⅛ inch diameter should be drilled in the center of each head to enable the connecting of the intake pipes. By the use of soft wire solder, the heads should be soldered into the ends of the cylinders, as shown at *d*.

"The pistons should now be made; for this purpose two additional male ferrules are required. These should be made to operate freely within the cylinders by twisting them in a rag which has been saturated with oil and upon which has been

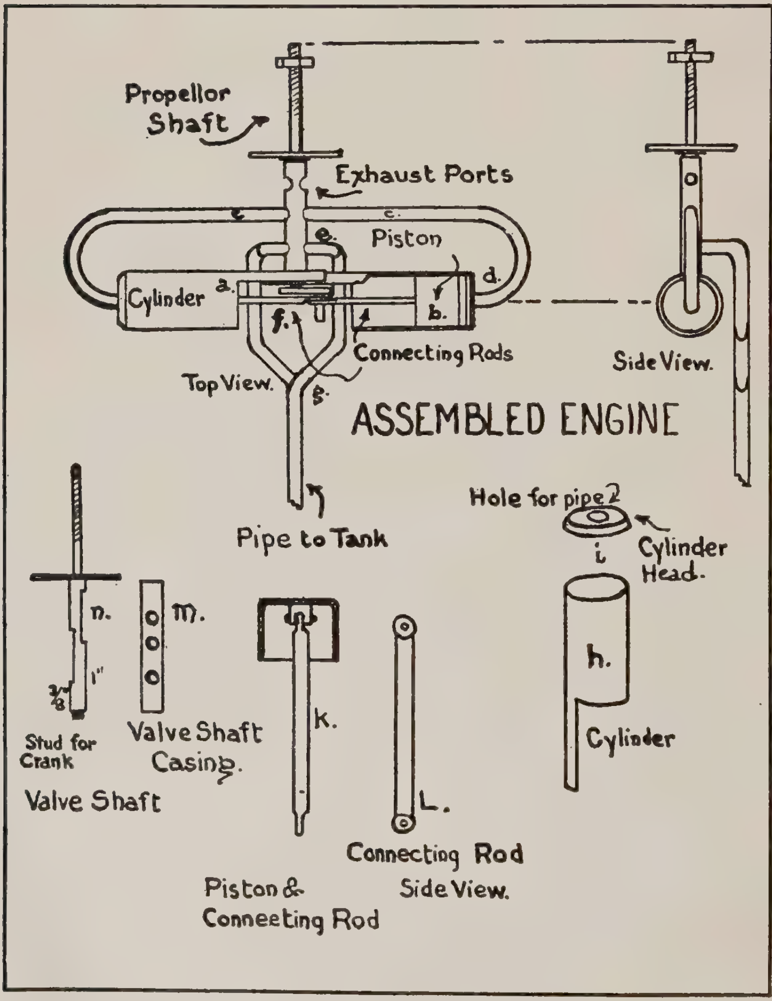


Figure 159. Compressed-Air Engine Construction

shaken fine powdered emery. When they have been made to operate freely they should be cut down one-half inch from the closed end, as shown at *k*. For the connecting rods, two pieces of brass tubing, each 1/8 inch in diameter by 1 1/4 inches in length, are required, and as illustrated at *L*, should be flattened out at either end and through each end a hole of 3/32 inch in diameter should be drilled. For the connecting of the piston rods to the pistons, studs are required; these should be cut from a piece of brass rod 1/4 inch in diameter by 1/2 inch in length. As two studs are necessary, one for each piston, this piece should be cut in half, after which each piece should be filed in at one end deep enough to receive the end of the connecting rod. Before soldering the studs to the heads of the pistons, however, the connecting rods should be joined to the studs by the use of a steel pin which is passed through the stud and connecting rod, after which the ends of the pin are flattened, to keep it in position, as shown at *L*.

"For the outside valve mechanism and also to serve in the capacity as a bearing for the crankshaft, a piece of brass tubing 1/4 inch in diameter by 1 1/2 inches in length is required. Into this should be drilled three holes, each 1/8 inch in diameter, and each 1/2 inch apart, as shown at *m*. Next, for the valve shaft and also propeller accommodation, secure a piece of 3/16-inch drill rod 2 inches in length. On the right-hand side of the valve shaft, as shown at *n*, a cut 1/32 inch deep by 1/2 inch in length is made one inch from the end. Another cut of the same dimensions is made on the left side; this cut is made at a distance of 3/8 inch from the stud end.

"As shown at *f*, the crank-throw consists of a flat piece of steel, 3/32 inch thick, 3/8 inch in length by 1/4 inch in width. At each end of the crank-throw a hole 3/32 inch in diameter should be drilled, the holes to be 1/2 inch apart. Into one hole a piece of steel drill rod 3/32 inch in diameter by 1/2 inch long is

soldered, to which the connecting rods are mounted, as shown at *f*. Into the other hole the stud end of the crank-throw is soldered.

"The parts of the motor are assembled by first fitting the pistons into the cylinders, as shown in Figure 159-*b*, after which the cylinders should be lapped one over the other and soldered, as shown at *a*. When this has been done, a hole ¼ inch in diameter should be drilled half-way between the ends of the cylinders, and into this hole should be soldered one end of the valve casing. For the inlet pipes, as shown in Figure 159-*c*,

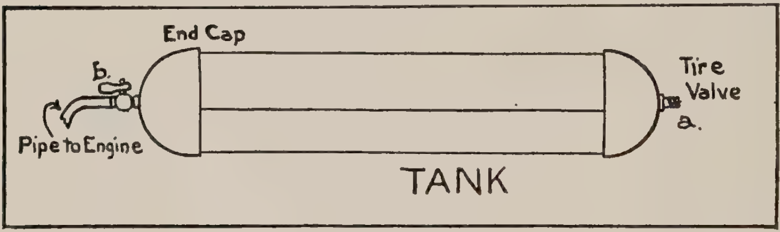


Figure 160

secure two pieces of ⅛-inch brass tubing and after heating until soft, bend both to a shape similar to that shown. When this has been done, solder one end to the end of the cylinder and the other in the second hole of the valve-shaft casing. The valve shaft should now be inserted in the valve-shaft casing and the connecting rods sprung onto the crank-throw, as shown in Figure 159-*f*. To loosen the parts of the motor which have just been assembled, it should be filled with oil and by tightly holding the crankshaft in the jaws of the drill the motor can be worked for a few minutes.

"The tank (Figure 160) is made from a sheet of brass or copper foil 15 inches by 10¼ inches by 1/100 inch in thickness. This is made in the form of a cylinder, the edges of which are soldered together as shown. Sometimes this seam

is riveted every ½ inch to increase its strength, but in most cases, solder is all that is required to hold the edges together. For the caps, or ends, the tops of two small oil cans are used, each can measuring 3 inches in diameter. To complete the caps, two discs of metal should be soldered over the ends of the cans where formerly the spouts were inserted, the bottoms of the cans having been removed. The bottom edges of the cans should be soldered to the ends of the tank. Into one end of the completed tank, a hole large enough to receive an ordinary bicycle air valve should be drilled (Figure 160-*a*). Another hole is drilled into the other end of the tank, into which is soldered a small gas-cock to act as a valve (Figure 160-*b*). These should be filed down where necessary, to eliminate unnecessary weight.

"To connect the tank with the motor, a piece of ⅛ inch brass tubing 5 inches in length is required, one end of which is soldered into the hole in the valve-shaft casing nearest the cylinders, as shown in Figure 159-*e*. As illustrated in Figure 159-*g*, a hole ⅛ inch in diameter is drilled in one side of the tube in the bend near the tank, and into this a piece of brass tubing ⅛ inch in diameter is soldered to connect the bend with the valve casing. The other end of the 5-inch pipe is soldered to the cock in the tank, thus completing the motor.

"In conclusion it is suggested that the builder exercise careful judgment in both the making and assembling of the different parts of the motor in order to avoid unnecessary trouble and secure satisfactory results."

Another source for the tank ends is found by taking apart a brass bed post. These are made in two pieces which are either soldered or pressed together. Bedpost balls have the advantage of being lighter than oil can ends. A form which tapers passes through the air a great deal easier than one which is of the same dimensions throughout. Therefore, in order to

secure a more airworthy model, some contestants may prefer to use different sized ends for their tank, joined by a taper-

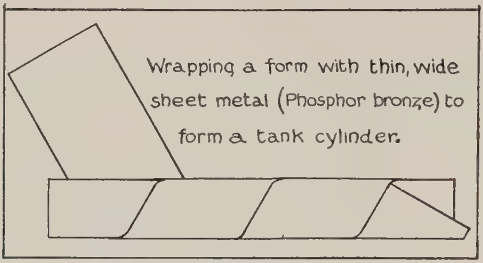
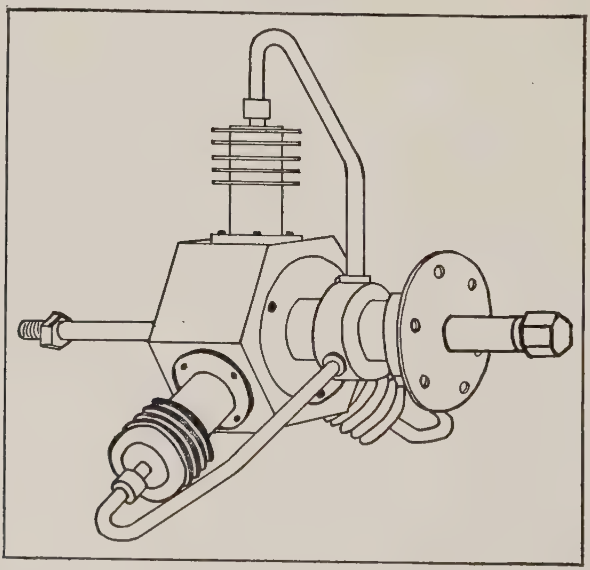


Figure 161

ing tube constructed in the same manner as that recommended in the foregoing article.

If it is desired to make a longer tank, the cylinder can be formed by wrapping a wide ribbon of sheet metal around a



(From: "The Modelmaker")

Figure 162. A Three-Cylinder Compressed-Air Engine

form like a spiral as shown in Figure 161, soldering each lapping, and finally wrapping the tank spirally with small piano wire. The wire turns should be about ¼ inch apart and four lines of solder should be run lengthwise of the tank to hold on the wire. After this it is removed from the form, the ends cut off even and the cups soldered on.

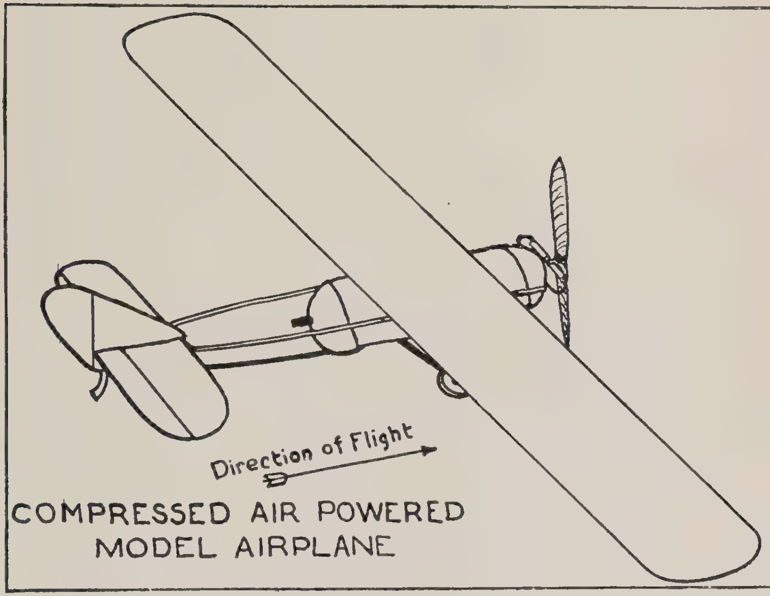


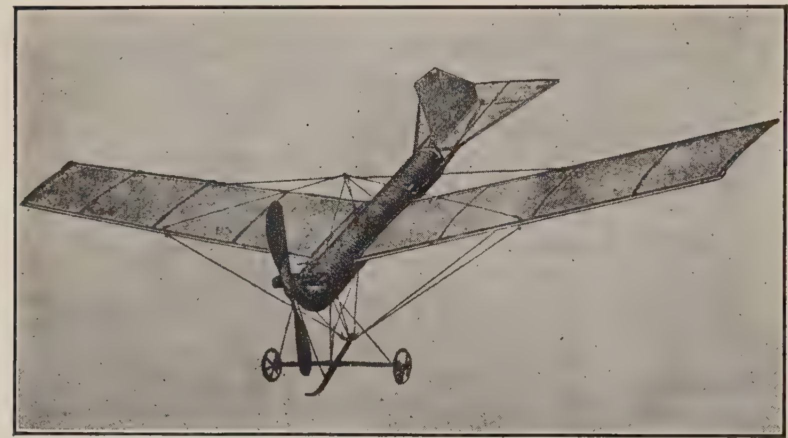
Figure 163

Figure 162 shows a three-cylinder compressed-air engine made on the same operating principle as the two-cylinder one, but in this instance the cylinders were turned on a lathe and the crankcase built up, using a three-throw spider for rod connection. Plans for such an engine were recently published in the magazine from which the drawing was copied.

The drawing, Figure 163, shows a typical compressed-air powered tractor monoplane. The tank is placed longitudinally in the body where it not only presents the least resistance to

flight but where its shape carries out the fuselage effect. The model has a wing spread of 4 feet, chord of 8 inches, length 30 inches. The construction of the wing, controls, etc., is similar to that of other models previously described.

Figure 164 shows another similar model having a tank 26 inches in length by 2 inches in diameter. Such a tank will hold



(From "The Modelmaker")

Figure 164. An English Compressed-Air Model

pressures of over 100 pounds per square inch. The model has a span of 5 feet, 9 inches, and length of 4 feet, 5 inches. This model has flown over 1,000 feet, after taking off under its own power.

Compressed air engines are energized by filling the tank with air by means of a tire pump, using a tire gauge frequently to be sure the tank does not have undue strain put upon it.

Although compressed-air models are more difficult to make than rubber-driven types, they give a greater mechanical pleasure but will not equal the distance and duration attainments of the lighter rubber-driven models because of the limitations of the tank.

CHAPTER XXII

MODEL AIRPLANE CLUBS

A model airplane club is a success if it has four features: *organization, membership, operation* and *incentive.* Clubs that are famous today and in healthy condition include all four features. Clubs which have passed out of the picture have done so because of the lack of one or more of these qualities. The author has seen many clubs started, some with a rush and roar, big mass meetings, speakers, promises, etc., and that was all that was done. But a club that is based on the four fundamentals above mentioned can not fail to thrive.

Organization. The backbone of a club is its officers and the rules that are agreed upon. The officers for a model aero club might be a president, secretary-treasurer, editor, stock clerk, and directors. The president should arrange for and preside at meetings. The secretary-treasurer is responsible for the roll, minutes, correspondence and funds, making note and report of all disbursements. The editor has charge of posting the club's bulletin board up to date, tabulating all records of flights, and operating the club's newspaper, if there is one. The stock clerk has charge of obtaining, preparing and selling supplies to the members, operating the stock department as a low-price distribution agency, making only sufficient profit to secure new stock and replacements. He would also have charge of the library. Some clubs have a ruling that their officers may serve only one season in any one capacity and then must either move up into another office

or return to the ranks of the members. The exception to such a rule is that the past presidents become directors and constitute an advisory board for the club. Honorary officials are good additions to a club, lending it prestige and support.

The club constitution may be patterned after any good constitution with wording to fit the local conditions. The various articles should cover such items as name, purpose, membership and dues, officers and their duties, committees, meetings, club device or trade-mark, and provision for amendment. The club should also have a good set of rules for conducting competitions.

Membership. First, the organizers should decide upon age limits, if there are to be any. The Playground and Recreation Association of America recognizes no minimum age limit but fixes the maximum age at 20. The best clubs, however, have many members who are adults, and because of long experience in the club they are wonderful helpers for those just joining. However, on account of competitions, it is best to divide the members into three groups: Junior, which comprises all from the minimum age limit to 15 inclusive; Senior, which includes those from 16 to 20 years inclusive, and Adult or Graduate, which includes those over 21 years. These can be further subdivided into candidates, apprentice members, regular members, associate members, corresponding members, etc. The entrance requirements should be such that both members and candidates will have a chance to study each other before admission. An appropriate initiation ceremony might be developed which would include agreement to abide by the club's constitution and rules, eagerness to learn modelmaking, intention to build a model within a specified time, etc.

Operation. Meetings should be held every week or every two weeks and at such times events should follow a prearranged

order of business such as: roll call, reading and correction of minutes, committee reports, unfinished business, announcements, new business, plans, elections, features, and adjournment. The meetings should be short and snappy, interest should not lag, and the business part of the meeting should be concluded promptly so that modelmaking, flying, clubroom decoration, and discussions, can be taken up. In regard to features, the Capitol Model Aero Club has a popular diversion called "ground school." On that occasion the members sit in rows and answer questions on model flying and aeronautics in general put to them by the Director. Those who miss a question must move their seat down the order of sitting, giving way to the one who answered the question correctly. At the conclusion of several rounds of questions the leaders in the sitting order are awarded some little prize, usually a piece of modelmaking equipment. Other features might be lectures by visiting notables or talks from one of the members on a newly discovered improvement in model construction.

The club should have a well-equipped stock department and library, and in addition, several work-benches and tools, with perhaps a circular saw and jig-saw for cutting strips and propeller blanks. The library should have numerous plans of successful models for the use of beginners and should have a representative technical library as well as interesting fiction stories on flight and allied subjects. A good plan is to charge a small sum for the use of the library books, devoting that fund for purchasing new books as they are published. There should also be a stock of jigs, tools, forms, propeller patterns, etc., which the members could borrow.

In holding its contests, the club should train various members to certain tasks, such as timers, recorders, flagmen, etc. Others should be responsible for bringing the contest equipment, such as repair kits, odometers, flags, stop-watches,

ground spikes, with rope and other items mentioned in Chapter XIII on Accessories.

The club should be alive to municipal projects and participate in them. In that way new members will learn of the club and desire to join it, and the community in general will appre-

Figure 165. Frequent Contests are an Incentive to Club Members

ciate and approve the advancing organization. Remember, "nothing succeeds like success."

Incentive. Upon the feature of incentive hangs the success of the others, for without desire to do, nothing will be done. One of the best ways to maintain members' interest is by obtaining and maintaining an attractive club room. Boys always like the feeling of possession and if they are made to feel a part of an organization that has an inviting meeting place, they will be inspired to attend meetings and assist in decorating and

preserving their club room. Decorations should consist of parts of aircraft, photographs of past contests, mementoes of former gatherings, well-made models that have won local records, trophies, etc. One club maintains what its members call a "rogues' gallery," wherein are framed the photographs and a short reference to the various members, partly descriptive, partly humorous. Not only does it serve to interest the regular members but candidates coming in can walk over to that section and read about their associates, learn their names, and addresses, and thus further acquaintance without delay and embarrassment.

A museum is a good decorative article for a clubroom, having in it scraps of models which cracked up under exciting circumstances, old-fashioned fittings, samples of joints and fittings for educational purposes, and parts of famous full-sized aircraft.

Competitions are wonderful sources of incentive and they should be frequently held. Awards and trophies should be given for leading performances. Local jewelers, newspapers, Rotary and Lion's Clubs, Masonic organizations, etc., should be asked to put up prizes for which the members could strive. The club itself should award some decoration, such as small wings, for progressiveness upon the part of a member. Cloth wings can be made to a design by the local dress trimmings store and presented in different colors for flights of 500, 1,000, 2,000 feet or durations of 30, 60, 100, 300 seconds, etc.

Some clubs have progressive systems of advancement similar to the first and second class and tenderfoot Boy Scout examinations. When a member has passed the stipulated study and achievements he assumes a new rank in the club.

The requirements prepared in Knoxville, Tennessee, for the local club are quoted here by permission, and may be adapted or revised for local use.

Kiwi. (An Australian bird that has wings but cannot fly)

1. Construct a box kite, Coyne kite, or tetrahedral kite capable of steady sustained flight for 10 minutes.

2. Construct a glider capable of a straight-away flight of 100 feet within an arc of 30 degrees.

3. Construct a model airplane carrying its own power, capable of flying 150 feet in distance or 15 seconds in duration.

Cadet. (In addition to filling requirements above)

1. Construct a model airplane capable of a flight of 300 feet in distance or 30 seconds duration.

2. Construct a balloon inflated with either hot air or gas, capable of remaining aloft 5 minutes.

3. Build a model airplane capable of flying 35 feet a second in still air. It must fly at least 100 feet.

Pilot. (In addition to filling requirements above)

1. Make a model airplane which will fly at least 500 feet or 45 seconds.

2. Make a model airplane which will fly at the rate of not less than 40 feet a second for at least 100 feet.

3. Build a scale model capable of flying 100 feet in distance or 10 seconds duration.

One of the nation's most prominent clubs has for the past seven years maintained an annual cross-continent race, in which its members are divided into two teams, each striving to advance its theoretical airplane across the continent. "Miles" are awarded for attendance, participation, model construction and performance, contributions to the club's scrap-book, museum, library, bringing in of new members, etc. At the end of the year the losing team has to treat the winners to a dinner and entertainment.

All of these suggestions have worked out in practice and are the reasons for the advance of the foremost clubs.

The first prominent model aircraft club was the Aero Science Club, founded in New York City in 1910. It rightfully boasts of many worthy members and has achieved dis-

tinguished honors in the model flying sport. Lieutenant R. S. Barnaby, U. S. N., was one of the founders of this club and because of the lessons learned at that time he was recently able to design gliders for the Navy which were launched from balloons and used in firing practice by anti-aircraft guns.

The Illinois Model Aero Club was founded in 1911 among members of the Aero Club of Illinois. Interest was aroused by

(Courtesy: "Aerial Age")

Figure 166. An Early Photo of the Illinois Model Aero Club

the founders who went among boys in the schools, Y. M. C. A., and other places lecturing on model flying. Such advertisement was productive of quick results. In December, 1911, their first contest was held at which a 90-foot flight attained first prize. From that start they rapidly advanced, holding frequent contests, each of which resulted in increased performances. In 1915 they broke four world records. This demonstration of ability attracted the attention of prominent citizens who offered cups for various attainments. These trophies were hotly contested. In 1920 and for several years since they conducted an interesting exhibition of model aircraft at the Chicago Pageant of Progress. In 1924 one of their members, Robert Jaros, established a world record duration

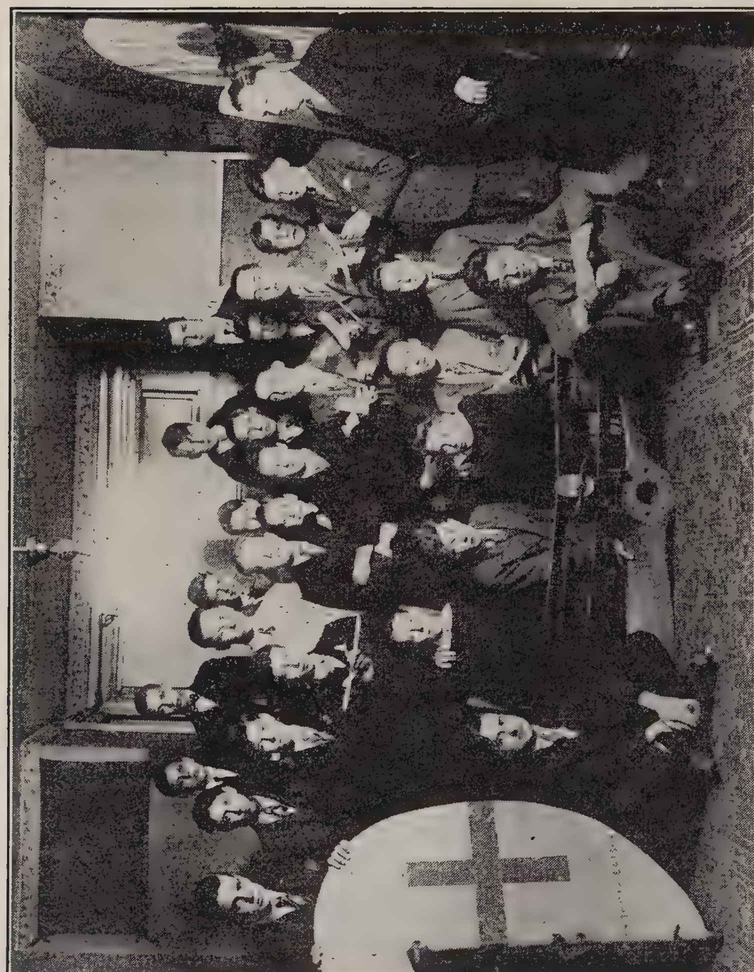


Figure 167. The Capitol Model Aero Club

(Courtesy: "The Washington Post")

for model flying of over 10 minutes which still stands unbeaten at time of writing. The club continues to progress, and as is tabulated in Chapter I, it holds nearly all of the present world records for models.

The Capitol Model Aero Club was organized by the author at Washington in 1913. Originally consisting of chums in

(Courtesy: "Popular Aviation")

Figure 168. The Akron Model Aero Club

grammar school, the news of the club rapidly spread as the members graduated and passed into the various high schools. The club continued a healthy existence until the war when most of its members joined the military services, the majority of course choosing the Air Service. One gave his life for his country. The others served with distinction. After the war a reunion was held and the club was reorganized; it continues to attract an energetic and capable personnel.

The Pacific Coast Model Aero Club was organized about 1915 among boys located in the cities from Seattle to San

Diego. Frequent correspondence contests were held and various cities challenged one another to their mutual advancement and pleasure. Their most recent acquisition is the dedication of a model aircraft airport in Los Angeles where model flights are frequently being held, resulting in much good advertising of the sport.

The Akron (Ohio) Model Aircraft Club was organized following the interest of officials of the Goodyear and Goodrich companies in the subject as a means of spreading aeronautical knowledge and enjoyable sport. They conduct many well attended contests.

The St. Louis Model Aero Club was first organized as a Chapter of the Capitol Model Aero Club, and has continued to do honor both to its source and itself. The distances and durations attained by them are very close to those which establish the Illinois Club as leaders. They have an excellent organization with a likable personnel and do much to boost aeronautics in their city.

Other prominent clubs are located in the Philadelphia Y. M. C. A.; Alton, Illinois; Peru, Indiana; and at Detroit the Michigan Model Club has made a name for itself in building unusually fine models and conducting well-organized contests. Cleveland, Ohio, and Kansas City have recently organized, and Knoxville, Tennessee, has a wonderful group of enthusiasts, ably led. Many other cities boast of fine model aircraft groups. It is hoped that the suggestions in this chapter will be the means of increasing the enjoyment and spreading the activities of all model clubs.

CHAPTER XXIII

MODEL AIRCRAFT CONTESTS

There are four elements that enter into the proper management of a model aircraft contest; these are the location, the officials, equipment and methods—each of which will be discussed separately. This Chapter also includes information about types of contests and a brief mention of several famous competitions.

Location. In regard to the location for an outdoor contest, it is desirable to have a large field that is centrally located but it is often difficult to find such a combination. The committee in charge of a contest should arrange for a field as large as possible so that the models in flight shall have every chance for success. It is very discouraging to see a fine model start for a long flight, only to run into a tree or other obstruction, ending its flight and perhaps breaking the model. If unhampered it might have established a new record. The best site should be chosen, such as a large meadow, airport, polo field, campus, golf course, or recreation field.

Flights should start from the side from which the wind is blowing, as models usually fly with the wind, but as launchings are usually made against the wind, the take-off point should be about 100 feet from the border, in case that border is lined with trees or houses. Models are launched into the wind in order to gain altitude, after this they circle and turn tail. The field should be accessible by trolley or road and should have accommodations for the comfort of con-

testants and spectators. It should be level, and preferably covered with a medium long grass to cushion the landings.

Officials. The officials should be a judge, recorder, timers, and assistants who might be termed flagmen and scouts. The duties of the judge are to have general oversight of the procedure, announce the contests, the order of flying, and name of each contestant as the model is launched. Other duties should be delegated to associated officials as it is necessary that the judge not be hampered by details, for many questions will arise to which he must be free to give attention, such as publicity, special announcements, decisions, etc. The recorder is supplied with the name of each contestant on proper tabulating sheets. He enters each flight as it is made and when the contest is finished he furnishes the judge with the results. The timers are obliged to time or measure each flight and communicate the result to the recorder.

The flagman stations himself some distance down the field and signals to the timers the termination of each flight. He is indispensable when a flight is of such length that the model is difficult to see from the starting line. The duty of the scout is to "police" the crowd keeping them away from the models and starting area; he obtains from the judge and recorder the order of flying so that he may circulate among the boys seeing that they are ready to appear immediately as each name is called. This is necessary, as often a contestant becomes so engrossed in the flight of a rival model or in the preparation of his model that he is surprised rather than ready when his turn comes.

Equipment. A few pieces of equipment will be required by the committee. The judge should have a whistle, watch, megaphone, and list of entrants, The recorder should have a list of entrants, pencil, and if possible be provided with table and

chair, as a fixed position enables the timers to know where to locate him. The timer should have a stop-watch, flag, and pad with pencil. The flag should be about one yard square attached to a staff. For distance flights, the timer should have a measuring tape, and if possible binocular field glasses. The flagman should have a flag similar to the timer's. The scout should have a list of entrants. Other field equipment should consist of the following: A starting platform; two enclosures for the Junior and Senior contestants in which to assemble and repair their models (these enclosures may have tables in them for work-benches); a rope or fence to hold spectators out of the flying area; and one or two motorcycles with sidecars for the use of contestants in regaining their models. The starting platform used at Memphis in 1927, was built of boards in the shape of a large shallow box-lid; for the hydro contests, this was inverted and filled with water.

Figure 169 shows a ground layout for a large tournament. The following directions with this layout will be found useful, but may be modified to suit local conditions. Some features may be eliminated if not deemed necessary. Many good contests have been held with scarcely any prepared accommodations, but the more systematic aid that is provided, the smoother the contest will run. Frequently contests are witnessed by numerous spectators who should be kept interested by a snappy program rather than tired by a series of postponements, delays, and dragging minutes.

In Figure 169 the relative location of the various features are shown. It will be noticed that the timers here are in three groups; for large official contests, three timers should time each flight to insure accuracy and prevent mishaps. If the three stop-watches disagree after a flight, the middle time is accepted. In case of two timers, the lower time is counted. Three groups of timers insure snappy progress of the flight program.

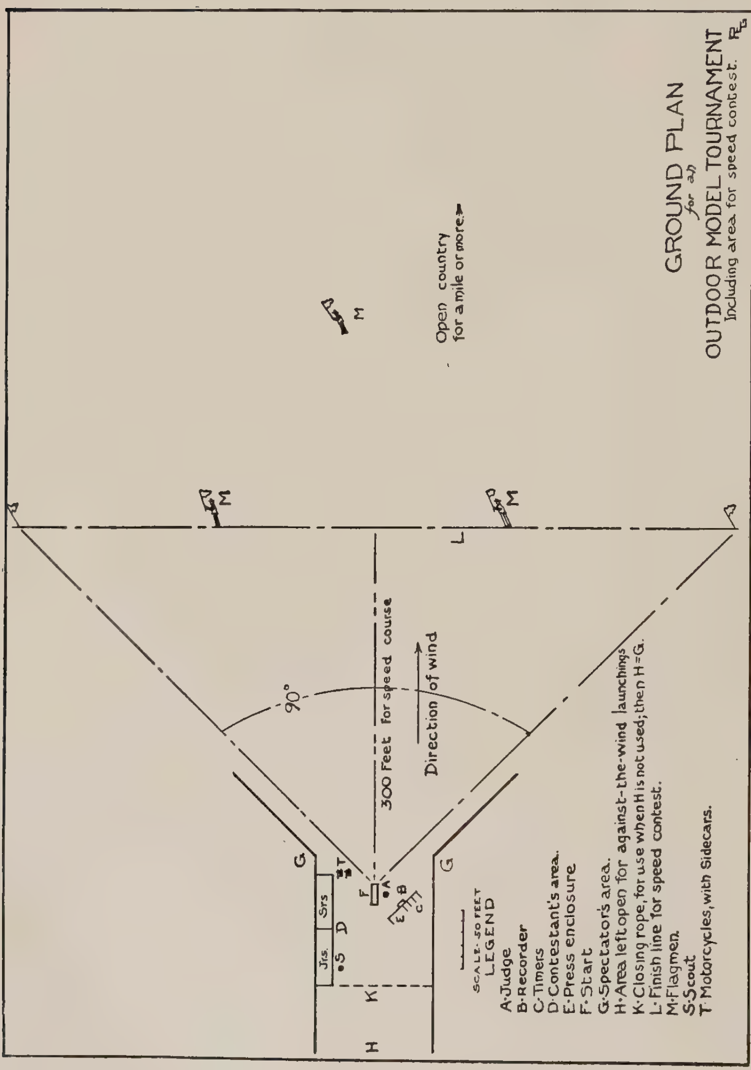

GROUND PLAN
for an
OUTDOOR MODEL TOURNAMENT
Including area for speed contest.
Open country
for a mile or more
300 Feet for speed course
Direction of wind
90°
SCALE: 50 FEET
LEGEND
A·Judge
B·Recorder
C·Timers
D·Contestant's area.
E·Press enclosure
F·Start
G·Spectator's area.
H·Area left open for against-the-wind launchings
K·Closing rope, for use when H is not used; then H=G.
L·Finish line for speed contest.
M·Flagmen.
S·Scout
T·Motorcycles, with Sidecars.
Jrs.
Srs.

Figure 169

How a Contest is Conducted

Now, to learn the method of managing a contest, imagine yourself at a model meet. The contestants have assembled at the field at the appointed hour, and distributed themselves in the respective areas—all of the ground layout and equipment having been prepared in advance by the judge and assistants. The judge makes a general announcement intended for contestants and spectators describing the nature of the contest, after which he instructs all contestants to come before the recorder to give him their names. A half-hour is now given up to the listing of contestants by the recorder; he enters them on the tabulating sheet and informs each of his flying number. (See Figure 170). Duplicate lists of numbers and names are handed to the judge and scout.

Meanwhile the contestants are preparing their models, the judge is giving final instructions to his assistants, press photographers are taking pictures, etc. At the conclusion of the preliminary period the judge makes sure all is in readiness. The contestants are warned that the meet is about to start; they are asked whether they understand the conditions and know their starting order. The timers assemble in their proper place. If three groups of timers are used, the flag for each group is a different color, and that carried by their flagman corresponds to it. In this way each timers' group has an individual flagman who watches every flight timed by them and assists in marking its extent. The scout sees that the contestants stop their trial flights and hold themselves ready to start in the proper order. Press representatives, honorary officials and others who have been permitted to come into the flying area are asked to remain in their assigned places so as not to obstruct the vision of the spectators or representatives. Now the contest starts.

The judge blows a whistle and announces the start of the

NAME OF TOURNAMENT

PLACE

DATE ....

NAME OF EVENT

CONTESTANTS	NO.	1ST TRIAL	2ND TRIAL	3RD TRIAL
JUNIOR				
SENIOR				

Figure 170. Suggested Form for Model Tournament Record

duration contest, calling Senior contestant No. 1 to fly. Meanwhile No. 1 has wound up his model and steps to the starting line or whatever spot in that vicinity he selects from which to start his model. The judge assigns timers' group 1, to this flight. At the moment the contestant releases his model, the timers all start their watches, one of them also raising the flag to let their flagman know that a model is in the air. They now keep their eyes and minds on that model to the exclusion of everything else. When the model touches the ground, their flagman drops his flag, they again click their watches, compare results and one of them puts the name and time on a slip of paper, delivering it to the recorder who enters it on the sheet as the first flight of No. 1.

Meanwhile, as soon as possible after starting No. 1, the judge calls No. 2 to the line, assigns him to timers' group 2 and that flight is begun, to be similarly conducted. No. 3 is cared for by timers' group 3, contestant No. 4, by group 1, who in all probability have finished with their first charge and are ready for another assignment.

So it goes, the judge keeping things moving just as fast as possible. When the list of Seniors has been completed once, the Juniors then begin, and when each of them has had a flight, the Seniors have their second chance. In this way the Seniors who had the misfortune to damage their planes in first trials, have the maximum time for repairs.

In order to conduct the competition expeditiously, a contestant must appear for flight within 20 seconds after his name is called; if not, he loses his chance to fly for that round. This may seem harsh but it is necessary and must be followed if model contests are to be interesting and managed according to schedule. Important competitions attract a large number of contestants; if no system is adopted much time is required to conduct a meet. By using the 20-second limit system and allow-

ing an additional 10 seconds for getting a model in the air, a group of ten contestants should require about 15 minutes to have three trials. But because time is required for winding up, for minor delays, and the general interest in an exceptionally good flight which is bound to hold up the procedure, it may be estimated as satisfactory if ten contestants are handled in twice the scheduled time, that is, a half-hour. But this can be reduced by cooperation with the judge by the officials, contestants, and spectators. A group that has been in contests before is much easier to handle than an inexperienced group.

Meanwhile the scouts have been circulating among the contestants helping with their models, warning them of starting time or order, winding models, and keeping the spectators away from the models. Spectators usually have their gaze toward the sky observing a model in flight rather than watching where they tread; consequently, unless they are kept away from the contestants the frail frames of models are liable to be broken. It is an axiom of model flying that careless feet have broken more models than have bad landings. Furthermore, the number of persons in the flying area must be limited to a minimum so that contestants will not have trouble in getting their models to and from the enclosure. Motorcycles have proved very useful for taking the boys out to their models and bringing them back after each flight, and should be used if the ground permits.

When the lists have been completed the three rounds, if time still permits, the ones who lost a turn because of tardiness may have a new chance to make up for the lost opportunity. If not, the contest, or that particular event, is declared finished. Then the recorder looks at each contestant's record of three flights and marks a circle around the best result. From those circled figures he chooses the first five, marking them with different-colored pencils, 1, 2, 3, 4 and 5. This sheet is de-

(Courtesy: U. S. Air Corps)

Figure 171. The First Mulvihill Contest, St. Louis, 1923

livered to the judge who may, in turn, hand it to a committee on awards.

The contestants can assist greatly in the smooth running of a tournament by making sure that each individual is ready

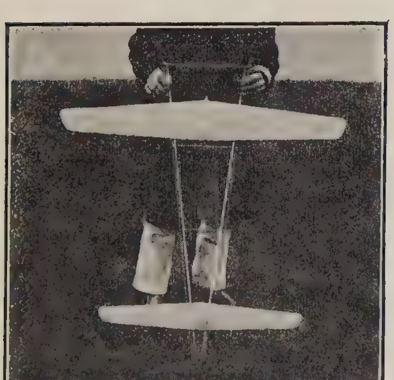


Figure 172. One of Heinrich's Models at the 1925 Mulvihill Contest, New York

Figure 173. Launching a Model at Philadelphia, 1926. Motorcycles are ready for retrieving the model

every time he is due to appear. Each will be given a number at the outset of a contest; this he should keep in mind. For instance, if one is No. 17,—when contestant No. 14 is called upon to fly, No. 17 should begin to wind his model, so that by the time 15 and 16 have flown their models, he is ready to launch without delay. When the judge calls name or number, he should answer "Here" and proceed immediately with the launching. If the model sets out for a long flight, he should get in one of the motorcycle sidecars or "bathtubs" as the boys call them, and follow the model, promptly regaining it at the end of the flight and returning to the flyers' area, where he should start preparations for his next flight.

The main item that delays contests is the preparation of models, therefore each boy should see that he is equipped to put his model in order quickly; furthermore he should be prepared to make repairs rapidly. Experienced contestants carry with them spare parts for their models, such as extra frames, wings, propellers, etc. The rubber strands are already made into hanks ready for attachment to the hooks. The model frames have marks on them so that the wings can be placed in the best position without need for trail flights at the contest. The contestants also have a little kit of tools and scrap material for making repairs.

If a contestant is fully equipped and has prepared everything for his model flights, and still has spare time, he should help those less fortunate. He can assist in placing wings and making repairs, and can wind up the models of those about to fly. All of the time, however, he should keep one ear open for the judge's announcements so that he will be ready when his turn comes. "Kidding" and "horseplay" should be discouraged at contests because in a moment of carelessness a model might be stepped on or a model box upset, causing serious misfortune to a fellow contestant. Finally, look out for the

models in the air, because one might fly over the contestants' area, dive and strike a person or model.

The Various Types of Contests

Various events are held at model tournaments, such as hand-launched, rise-off-ground, hydro contests, speed contests, etc. The following paragraphs discuss special features of each type of event.

Hand-Launched. A hand-launched outdoor contest has just been described. The only requirement made by the P. R. A. A. is that launchings must not be above 6 feet from the ground or floor. This height can be determined by an upright of that length placed at the starting point. To be sure the models are within the sizes specified, they should be inspected and measured. Every contestant should state or declare in writing that his model is made by himself without assistance. If a model while in flight, strikes some object, that ends the flight unless the model regains equilibrium unaided and continues flying without having actually come to rest.

R. O. G. Contest. A rise-off-ground contest requires a starting platform or a long strip of linoleum. The time or distance of flight is taken from the moment or point of take-off until the model again touches the ground; not from the moment of launching to the time when it stops rolling. Models must carry their chasses in flight.

Distance Contests. Distance contests are somewhat more difficult to judge than duration contests because of the time consumed and physical labor required for measurements. This may be done with a tape line, but an odometer, as described in Chapter XIII does quicker work, and if accurate, it is just as good, and less tiring than using a tape. In order to facilitate

the measurements it is well to have the area marked off by flags into 100, 250, 500, 750, 1,000 feet and possibly larger circles so that a model landing near a flag can be measured from the flag rather than from the starting line. Exceptional flights may extend much beyond 1,000 feet.

R. O. W. Contests. Rise-off-water contests require a large water area or a starting tank. This tank should be placed in a grassy field so that the float chassis will not be wrecked by hard landings. If the community is so fortunate as to have available a large lake, tidal basin, or tranquil river, it is advisable that launchings be made from the water's edge so that spectators may witness the starts without requiring the contestants to go out on the water in boats. Because of the difficulty in using a tape line over a water course, hydro flights are measured for duration only. The duration is taken from the moment the model leaves the water till it touches water or land again, preventing further flight. A fast launch should be used to regain the models from the water, because sometimes in alighting they go under and if not quickly located may disappear; the propellers may contain some unused power, thereby forcing the models along in the water while the wings act like the vanes of a submarine to hold the model under.

Weight-Carrying Contests. The weight-carrying contest requires a smooth take-off platform exceptionally long because a model burdened with a weight requires more take-off area than one not so loaded. The scale used should be graduated in small units and have a large pan for supporting the model. Medical supply houses sell such a scale which is used in the profession for weighing food for persons on special diets. It weighs in grains or grams, and being a spring scale requires no weights. In addition, a small quantity of thin sheet lead should be at hand for flying weights.

Figure 174. The Line-Up Before the Contest

Figure 175. Walter Roth of the C. M. A. C.

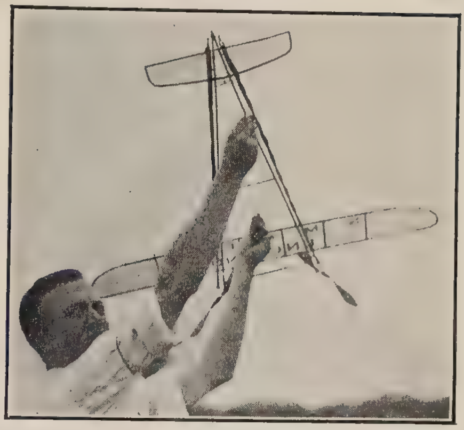


Figure 176. One of the English Entrants

Figure 177. Jack Loughner of Detroit. His Winning Entry

SCENES AT THE INTERNATIONAL CONTEST FOR THE MULVIHILL TROPHY, PHILADELPHIA, 1926

In starting a weight test, the model is first flown empty to make sure it is in proper trim, then the center of balance is found and at that point a small piece of lead is bent around a strut, spar, motor stick, etc. Thus loaded, the model is again flown. Regulations state that a model must make a minimum flight of so many seconds in order to qualify as having flown with the weight. The P. R. A. A. specifies 8 seconds. If the model when weighted flies more than the specified time it can be loaded heavier. If less, weight is taken off. Finally when the model has carried a load to the limit of its capacity for the required duration, the weight ratio is determined. The formula for this is:

$$\frac{L}{W.P.+L} = \text{Weight ratio}$$

This means the load L is divided by the weight of the plane $W.P.$ added to L. For instance, suppose a model weighing 175 grams flies 8 seconds with a load of 34 grams, then our problem would be:

$$\frac{34}{175+34} \text{ or } \frac{34}{209}$$

which is .162 weight ratio.

Before competing at a tournament, the contestant should have determined the ability of his model so that he knows approximately what load it will carry in flight; then he can ask the judges for the proper quantity. At an official tournament each launching counts as a flight regardless of the duration attained. At the Memphis contest in 1927, C. Krejci, of Chicago, made the excellent weight ratio of .454, showing that his model could lift nearly half again as much as its own weight.

Speed Contests. As shown in Figure 169, the area for a speed contest is marked with the finish as a straight line 300

feet distant from the starting point. The distance is measured along the bisector of the flight area which is a 90-degree sector with its apex at the starting point. Models are launched from the apex at the starter's word "Go," at which instant the timer will click his stop-watch. In order that the timers can determine when the model crosses the terminal mark, an official will be stationed at one end of the finish line with a flag which he raises when he sees the model launched. At the instant the model crosses the line, the flag is swished to the ground. The timers will see the downward swoop of the flag and click their watches.

In order to compute the performance of a model in miles per hour, resulting in a figure more understandable by spectators and contestants, use the following formula (for 300-foot course only):

$$\frac{3{,}600}{T \times 17.6} = \text{Miles per hour}$$

Simply explained, the time (T) made by the model is to be multiplied by 17.6 and the answer divided into 3,600. For example, let us suppose a model has just flown the 300-foot course in 7.4 seconds. Therefore, 7.4 x 17.6 equals 130.24 which goes into 3,600 a trifle more that 27.6 times, which is the number of miles per hour the model made. (3,600 is the number of seconds in one hour; and 17.6 results from dividing 5,280—feet in a mile—by 300.)

Altitude Contests. Comparative altitude flights are hard to judge. The only accurate method is by triangulation, using two instruments, widely separated and equipped to measure both vertical and base angles. The method would be understood by a student of trigonometry, but because of its complicated nature it will not be included here. Should any

(Courtesy: Recreation Department)

Figure 178. A Contest at Waterbury, Connecticut, 1927

contest committee desire to employ it, their local mathematics instructor could explain the computations to them from the above reference. Disregarding the above it can be said that the only practical way to decide an altitude contest is by agreeing with the judge's opinion.

One type of altitude event that is easier to judge is a rise-off-ground contest in which the models are required to clear a line suspended horizontally about 40 feet in front of the starting line. It might be called a quick-rising or hurdling contest. The model that clears the line from the nearest point or passes the highest above a given point would win.

Acrobatics. Acrobatics simulates stunt flying. Models for this contest should be high powered and equipped with flexible control surfaces. One form of competition might be to see which model could execute the most loops or most horizontal circles or make the greatest number of twists and turns. Such a contest is exciting and interesting. A more scientific acrobatic contest is the execution of a given maneuver by a model. A "figure 8" turn is an example. In order to qualify, the model would be required to make first a right turn, then a left half-circle, then a right turn again. This is an excellent means of developing ingenuity among the contestants and forcing them to study air laws. To accomplish a "figure 8," the elevator could be warped by pulling threads wound on a shaft which would turn as the propellers revolved; or a rudder might be similarly operated. Another acrobatic test would be to see which model, when launched upside down, could right itself from the lowest initial elevation. These examples naturally will suggest others.

Workmanship and Design. A contest of this type requires a competent corps of judges who shall comprise skilled crafts-

men as well as aeronautical experts. The former would judge the neatness and excellence of workmanship. The latter would pass upon the accuracy to detail. The age and training of the

Figure 179. The Line-Up at Memphis, 1927

contestant would be an important factor in such a contest. Ratings would be given upon a percentage system, such as: neatness of joints, 10%; rigidness and strength, 15%; finish,

Figure 180. "Billy" Brock (Illinois M. A. C.) winding Lefker's Model preparatory to its Record-Making Flight at Memphis, 1927

including smoothness and tautness of fabric, neatness of paint and trim, absence of careless smudges and patches, etc., 15%; general accuracy to the original, 25%; proportion of parts, properly one to the other, and detail, 10%; ingenuity of maker in forming parts from odds and ends, 10%; evidence of a knowledge of aeronautical facts shown by features of the model, 15%.

Kite Tournaments. Contests with kites are dependent on the weather for success, much more so than model airplane contests, but because of the general familiarity with kites and the impressiveness of many kites in the air, kite tournaments are popular spectacles. The following events are here included through the courtesy of the Houston Recreation Department, which is well versed in kite flying.

1. Highest kite. All contestants after registering may put their kites in the air for this event. An airplane, through the courtesy of a neighboring airport, could best judge this event, making the flight over the field at an appointed time.
2. Most unique kite.
3. Smallest kite. Must soar at altitude higher than mooring point and must carry at least 25 feet of string.
4. Strongest puller. Must not be larger than a specified size. Pull to be measured 3 times with a spring balance attached to a loop in the kite string.
5. Largest kite. Limited to single plane types.
6. Most artistic kite. Based on beauty of construction, gracefulness in flight and artistry of design.
7. Steadiest kite. Limited to tailless kites.
8. 220-yard dash. The kites are to be flown on a 220-yard length of string. At the signal the contestants who are 50 yards away will race to their respective kites and reel them in, using a single stick. The shortest time wins.

All kites must fly a specified time.

Plans for Tournaments

A community that intends holding a miniature aircraft tournament should do five things. First, form a committee composed of prominent persons who by their knowledge and prestige could give proper backing to the project. Second, arrange that the contestants can readily secure proper plans and plenty of material at reasonable prices. Third, plan a series of contests in which the participants will be conducted step by step through the various phases of modelmaking so that complete knowledge will be imparted and difficult steps will be smoothed by sufficient training. Fourth, so arrange the local schedule that it will tie in with national contests; thus local participants will be eligible for national honors. Fifth, arrange for suitable and desirable awards as incentives for the contestants in addition to their pleasure in the sport.

Such a plan could be arranged somewhat as follows for spacing a group of contests throughout the spring and summer:

March 1. General get-together meeting indoors. Lecture on the sport. Flying-top contest. Announcement of plans.

March 15. Contest with elementary aircraft such as kites, boomerangs, gliders, etc. Demonstration of flying models by experts.

April 1. Indoor contest with single pushers. Lecture on outdoor scientific models. Awards.

April 15. Outdoor contest with single and twin-pusher models. Demonstration of tractor model.

May 1. Indoor contest with indoor tractor models. Demonstration of small chassis model and lecture on wheel and land chassis construction. Awards.

May 15. Outdoor contest for tractors. Demonstration of outdoor R. O. G. model.

June 1. Indoor contest for R. O. F. (rise-off-floor) models and demonstration of scale model. Awards.

June 15. Outdoor contest for R. O. G. models, general re-

view, pushers and tractors, acrobatic contest. Demonstration of hydro model.

July 1. Indoor contest, scale models R. O. F. Explanation of weight carrying. Awards.

July 15. Outdoor contest, for R. O. W. models.

August 1. Indoor contest. Workmanship and design competition. Weight-carrying contest. Indoor hydro contest. Awards.

August 15. Outdoor contest, for speed.

September 1. Elimination contest for national tournament. Final competition and general review among contestants who won the first ten places in previous events. Hold local duplicate of national tournament. Outdoor events in the day. Indoor events in the evening. Announcement of local representatives to national tournament. Awards.

October 15. Indoor mass meeting. Discussion of past season and plans for winter indoor contests, lectures and possible use of model aeronautics in the schools as part of the manual training program. Special awards for results in past season, such as a cup for the contestant whose total flying time exceeded all others, or for most models made or most points gained. Points could be awarded on the basis of 5 points for a first place, 4 for a second, 3 for a third, 2 for a fourth and 1 for a fifth. The keeping of records and points is quite important and should be done systematically upon a suitable printed card.

National contests are the classics of model flying. There are at present several contests yearly which attract model flyers from the length and breadth of the country. The Villard Cup was formerly contested by correspondence; that is to say, properly attested records were sent in to a central body that awarded the trophy to the highest score. This cup was finally won by the Illinois Model Aero Club in 1919. The Mulvihill Trophy has been in annual competition since 1923 with the exception of 1927. In that year the Playground and Recreation Association of America conducted its first National Tournament in which a very wise and fair distinction was inaugurated

among model flyers based on age; those below 16 being termed Juniors and those from 16 to 20 inclusive as Seniors. The P. R. A. A. National Tournaments are held each year in a different city from that of the previous year in order to avoid localization. The events on that occasion include nearly every phase of model flying.

A typical program is as follows:

Indoor Events

All indoor airplane models to be limited to 30 inches in length or span. Hand launchings to be not over 6 feet from floor.

1. Junior Class. Gliders, hand-launched at a point not higher than 6 feet above the floor; for duration. Each flight must terminate at least 20 feet from the starting point.
2. Senior Class. Same.
3. Junior Class. Scientific models, rubber motor only, hand-launched for duration.
4. Senior Class. Same.
5. Junior Class. Scale models, power optional, rising-off-floor for duration.
6. Senior Class. Same.
7. Junior Class. Scientific or scale models, power optional, rising-off-water for duration.
8. Senior Class. Same.
9. Junior Class. Weight carrying contest. Scale models only with rubber power, rising-off-floor; minimum flight of 8 seconds needed to qualify. Ratio of weight of load to weight of plane plus load only factor to be scored.
10. Senior Class. Same.

Outdoor Events

Models must not exceed 48 inches in length or span. Tractor or pusher. Hand-launchings to be not over 6 feet above ground.

1. Junior Class. Scientific model airplanes with rubber power, hand-launched for duration.

2. Senior Class. Same.

3. Junior Class. Scientific or scale models with any motive power other than rubber. Launching optional for duration of flight.

4. Senior Class. Same.

5. Junior Class. Scale models with rubber power, rising-off-ground for duration.

6. Senior Class. Same.

7. Junior Class. Scientific or scale models, power optional, rising-off-water for duration.

8. Senior Class. Same.

9. Junior Class. Speed contest. Scientific models, with rubber power, hand-launched. Flight to be with the wind. (Ground layout same as Figure 169.)

10. Senior Class. Same.

At the P. R. A. A. tournaments, handsome cups, trophies and medals are awarded successful entrants. These are given the winners in each event who are the leaders in the point system based on five places, in the same manner as advocated for "Local Contests."

William B. Stout has presented a cup for annual competition, the conditions of its award being varied from year to year. It is a much sought after trophy. It will be observed that in the tentative list for local competitions the author provided for a mid-year tournament by suggesting a review, or elimination contest in early June. This would permit local entries to compete for such trophies as those awarded by Messrs. Mulvilhill and Stout.

Several prominent magazines are offering prizes for model competition. Model aeronautics is advancing so rapidly and finding such favor that its popularity no doubt will be encouraged by other trophies from time to time, but nevertheless the contests having official sanction and established prestige will continue to be the greatest attraction.

CHAPTER XXIV

THE USES OF MODEL AIRCRAFT

In addition to the value as a recreation, model aeronautics plays a prominent part in the industrial and commercial development of the world. One who adopts model building and flying as a hobby is fitting himself in a very enjoyable way for a part in life.

Model aircraft have contributed much to the present efficiency of man-carrying aircraft. This fact is traceable through the entire history of flying. Men have always longed to fly. Transportation on the ground has ever been difficult; it has been necessary to clear a road through paths beset with trees and rocks, to fill depressions, tunnel through mountains and bridge over rivers. In the midst of these labors men have envied the birds their ability to fly unhampered through the universal highway of the air. Unable to build a flying machine because of lack of knowledge and tools, early man imagined that his religious Gods could fly; to him they represented beings who were all-powerful and who, in their infinite wisdom, used the most efficient transportation for accomplishing a purpose. The Babylonians illustrated their God, Itana, riding about on the back of an enormous bird; the Hebrews and Orientals believed in Solomon's flying mat and the magic carpet; the Greeks and Romans endowed their God, Hermes or Mercury, with winged sandals and cap; the Christian religion illustrates angels with wings to aid their missions of mercy. The bards and minstrels of early days thrilled their hosts with stories of flight such as those of Daedalus and Icarus, Pegasus the

(Courtesy: U. S. N. M.)

Figure 181

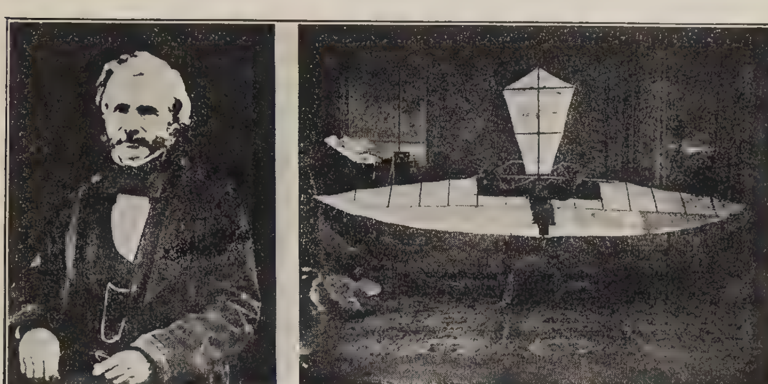
winged horse, and the magic carpet; stories which were so entertaining that they have been handed down to modern times and are still interesting.

The story of the first man-made flying device concerns a time so long ago that it, too, may be a legend, but as all legends usually are based on some degree of fact, we will include the story here; it is particularly interesting because of its statement that the first flying machine was a model airplane. It is chronicled that 400 years before Christ there lived in Tarentum (Now Taranto, southern Italy) a wise philosopher named Archytas, who made a small wooden pigeon propelled by "ethereal air." The device is said to have flown about 50 feet. Ethereal air probably meant compressed air, and the device must have moved by reaction, just as a toy balloon rushes about when the neck is opened and the air within escapes.

Following Archytas was a time known as the Dark Ages when all learning was practically at a standstill; during this period the only reference to flight was the superstitious mention made of demons and witches. With the renaissance or reawakening of learning, Leonardo da Vinci, the great Italian genius, gave aviation its real start. He studied the flight of birds and made many models representing the new ideas. He designed a man-carrying machine with flapping wings, but as he intended it to be operated by man-power only, it would have been unsuccessful as no man can maintain the strenuously rapid motions necessary for flight. However, da Vinci's work was such a great advance over previous superstitious suggestions that several experimenters actually tried to fly with flapping wings, notably Allard in 1660, Besnier in 1678, and deBacqueville in 1742. They had little or no success, but in 1783, as told in Chapter XX, the invention of the balloon took men's attention away from heavier-than-air machines to those

lighter than air. However, as Monsieur Charles in France practically perfected the hydrogen balloon by 1800, the more energetic experimenters soon returned to dynamic machines because they represented true flight and not mere floating.

The man who led this return was Sir George Cayley of England. He too made model airplanes as well as gliders

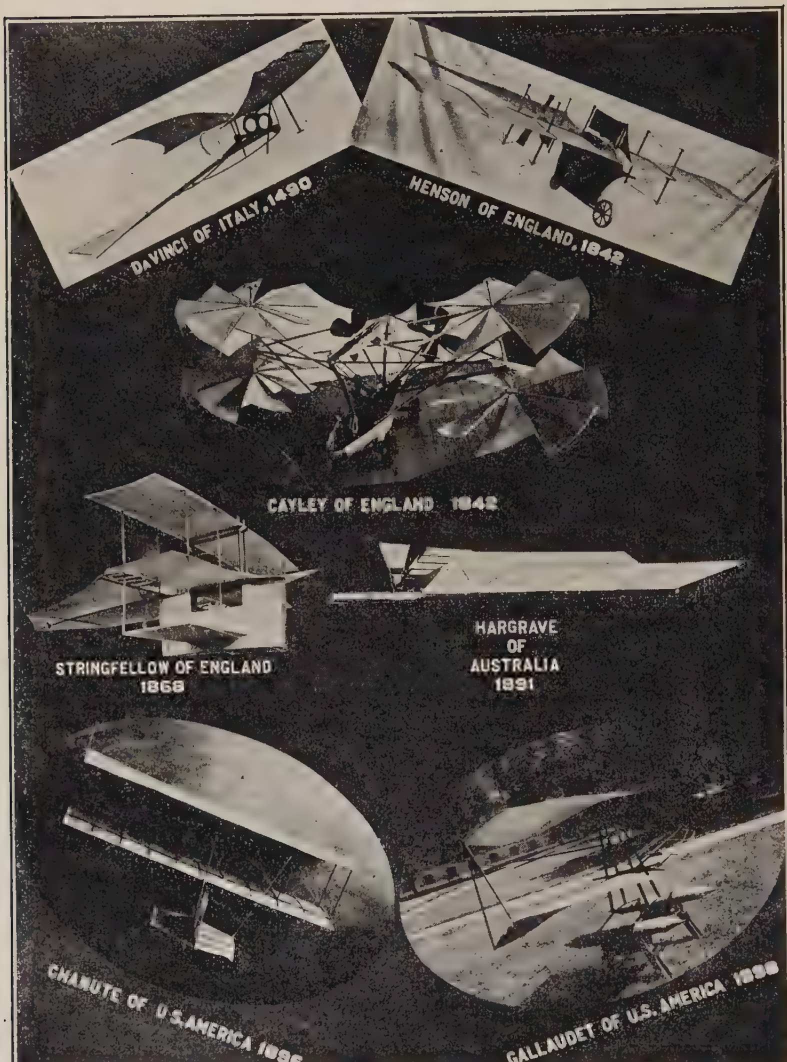


(Courtesy: U. S. N. M.)

Figure 182. Stringfellow and His First Successful Model

and even designed larger machines with power plants. Acting upon his principles, Samuel Henson and John Stringfellow planned to construct a huge air liner, and as the first step they made some models. The performance was not convincing to the public and the two inventors could not get financial backing for their project. Henson became discouraged, and emigrated to America, but Stringfellow persisted. The engines which he made were marvels of combined lightness and power. He too experimented with models; finally in 1848 he succeeded in launching one from a wire for a short flight. Disregarding Archytas as mythical, it may be said that Stringfellow's model was the first machine to fly.

Encouraged by this success, others tested their ideas for flight with models as there was no engine which combined



(Courtesy: U. S. N. M.)

Figure 183. "Famous Model Airplanes." The three at the top are reproductions made by the author. The others are original historical specimens.

adequate power with sufficient lightness to be embodied in an airplane. Experiments were conducted with three classes of flying machines: ornithopters or bird-like wing-flapping ma-

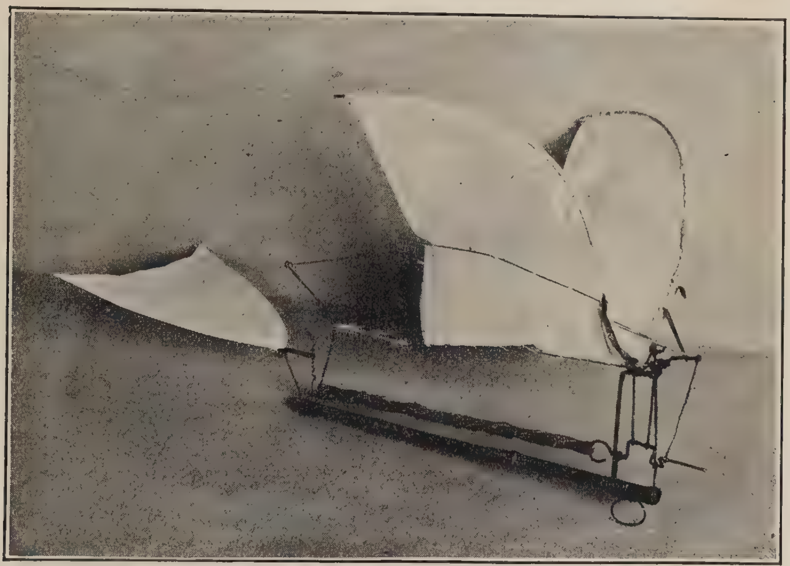
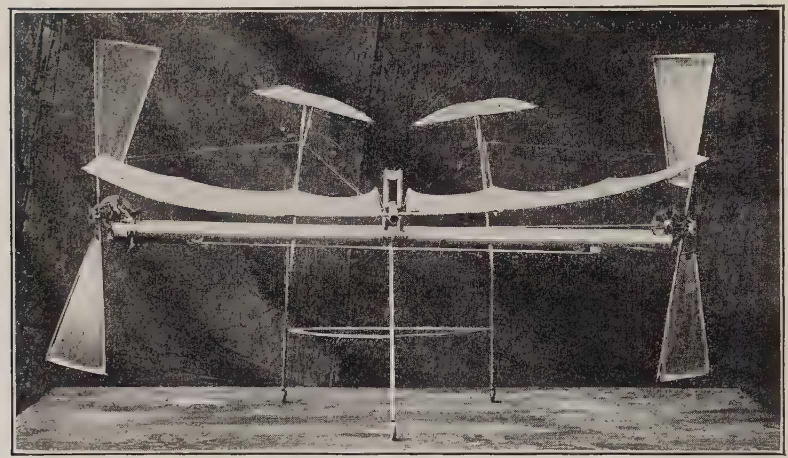


Figure 184. Pichancourt's Ornithopter, 1889

chines; helicopters or machines with vertically acting propellers, and airplanes which have rigid wings that derive lift from the reaction of the atmosphere against their wings. Figure 183 shows several devices of the early days in aeronautics.

The Stringfellow model illustrated in this group is another one of Stringfellow's machines, and includes an engine which in 1868 was awarded a prize as being then the lightest engine per horsepower. Lawrence Hargrave is best known among boys for his invention of the box kite, but during experiments he not only used cellular devices but also single surfaces. The device illustrated (Figure 183) was powered with compressed air; it made a flight of 391 feet, being at that time the greatest

success since Stringfellow. Chanute was a mechanical and civil engineer who made many gliders and thus developed efficient wing shapes and surface combinations. Edson F. Gallaudet made the device illustrated to be flown as a kite for testing wing



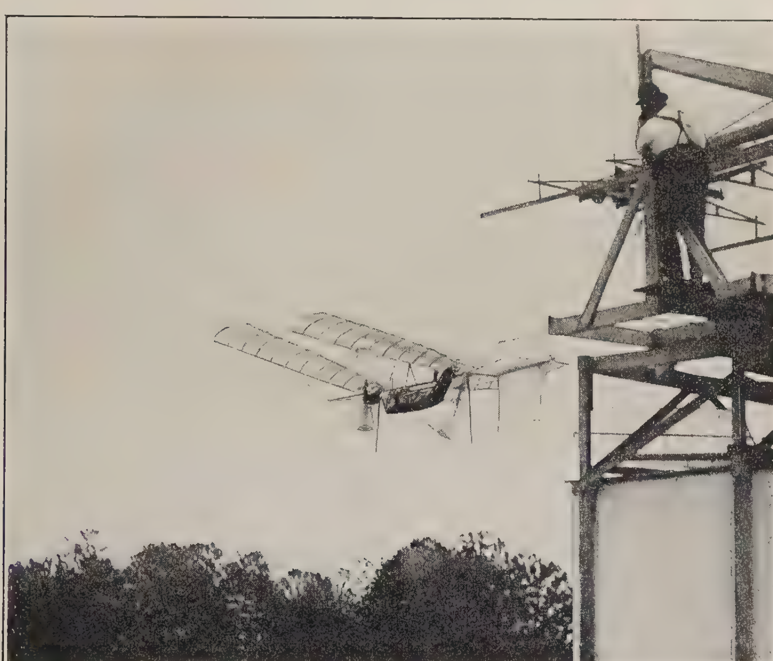
(Courtesy: U. S. N. M.)

Figure 185. One of Langley's Early Rubber-Driven Models

warping as a means of steadying an airplane. He has since become prominent in the manufacture of successful commercial and military airplanes.

Samuel Pierpont Langley was a great user of models for aeronautical research. He tested various ideas for wing surfaces by employing models whirled through the air upon an extended arm. He made numerous and exhaustive experiments with rubber-driven models using rubber both stretched and twisted. Realizing that his models could better illustrate the essential features if flown for greater duration, he made a large model 14 feet in span and powered it with a one-horsepower steam engine. Several trials with resulting modifications were made and in 1896 his No. 5 was ready for test.

These trials were extremely successful for on May 6 of that year No. 5 made a flight of ¾ of a mile staying in the air nearly a minute—a great improvement over his predecessors. This model weighed 26 pounds and was launched



(Courtesy: U. S. N. M.)

Figure 186. The Launching of Langley's Steam-Driven Model No. 5, May 6, 1896

from a catapult as shown in Figure 186. With this successful model as a basis, he developed several others including one powered with a small radial gasoline engine of 3.2 HP. which accomplished the first gasoline-powered flight ever made; this was the ¼ size duplicate of the full-sized machine made in 1903. All of Langley's machines are preserved on exhibition in the U. S. National Museum.

The Wright brothers began their experiments with models. It is related that when these famous brothers were young, one day their father brought home a small model similar to a Dandrieux butterfly (See Figure 187). When released it

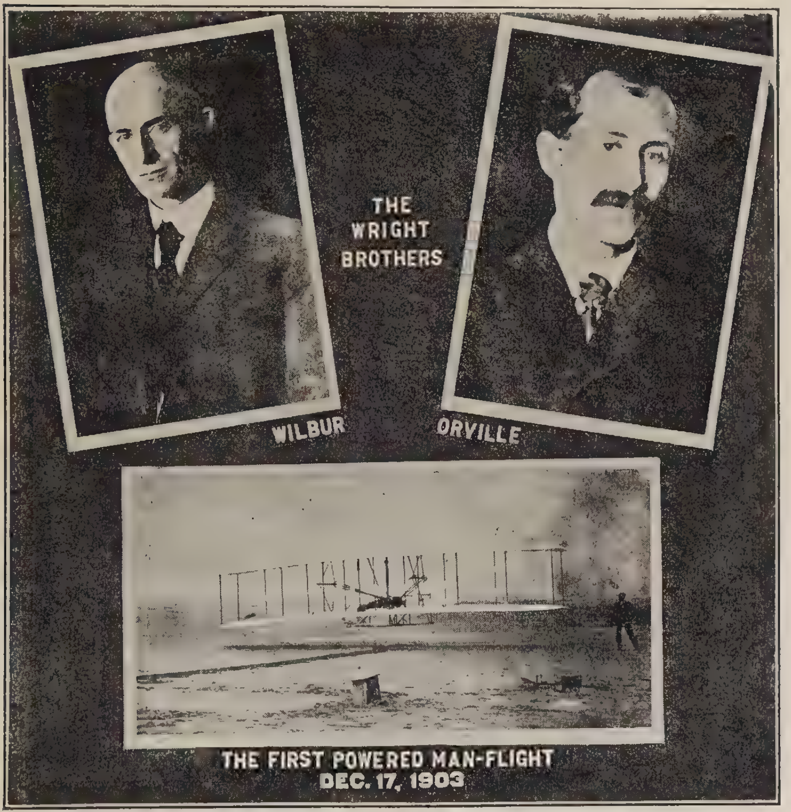
(Courtesy: U. S. N. M.)

Figure 187. A Dandrieux Paper Butterfly, of 1879. Such a model started the Wright Brothers in aeronautics

flew to the ceiling, fluttered there a moment then fell. It was eagerly examined by the boys and they flew it again and again, marveling at the performance. Soon they were making similar models embodying their own ideas. As the brothers grew older, it was but a step from their successful models to the making of a man-carrying glider in which every feature was the result of careful thought and trial. Desiring to test this invention they enquired of the Weather Bureau as to the locality best suited for gliding experiments. They were told that the wind blew steadiest on the sand dunes of North Carolina.

Accordingly their glider was taken to the little settlement of Kitty Hawk, where gliding was practiced until they were masters of their craft. The next desire was to put an engine into their glider, but an engine light enough was not available. Undaunted, they built one, installing it in a stronger and larger machine, and on December 17, 1903, with Orville in the ma-

chine and Wilbur assisting on the ground, the Wright brothers made the first fully controlled, man-carrying flight in the his-



(Courtesy: U. S. N. M.)

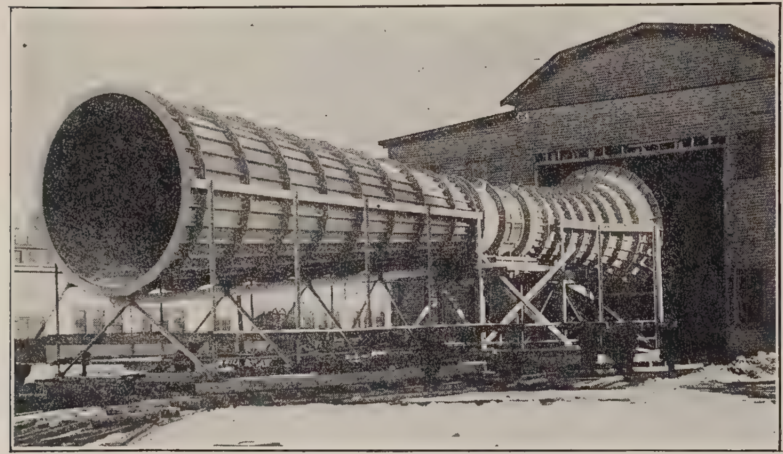
Figure 188

tory of the world, realizing the human desire of centuries and winning well merited praise and eternal honor.

Thus, with the realization of man-flight, we have learned how the model airplane was most useful toward the final accomplishment, and how models, by their flights, kept alive the belief in ultimate man-flight during a period when many

were discouraged by lack of suitable power for full-sized experiments.

But the contributions of the model airplane to human flight did not stop there. Inventors who sought to improve their machines used models to test their ideas. The Wright brothers

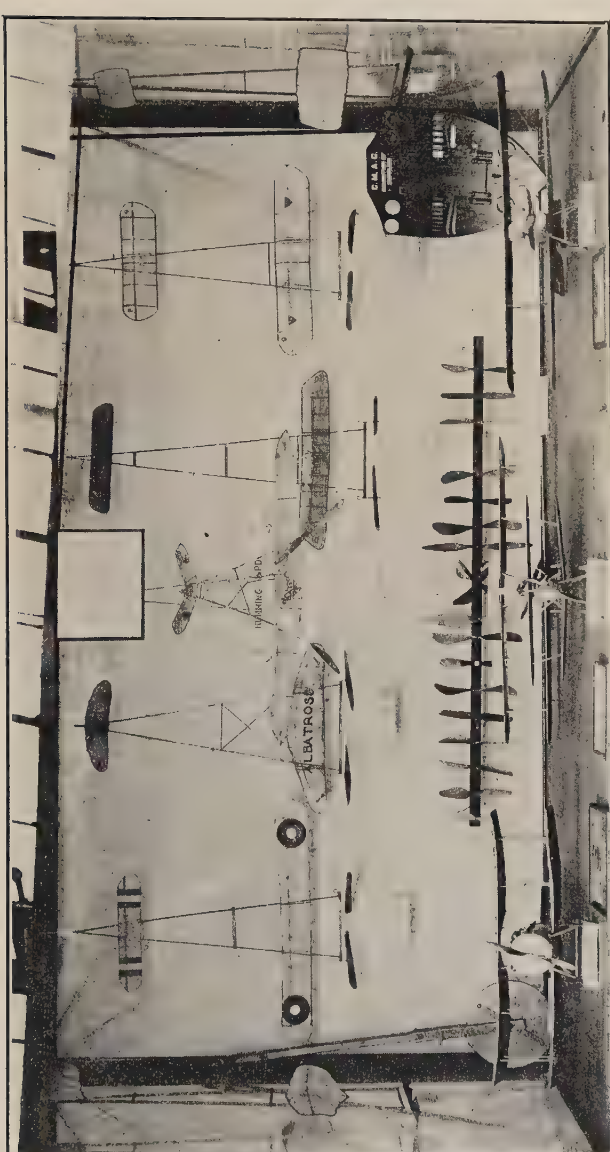


(Courtesy: M. I. T.)

Figure 189. The Wind Tunnel at Massachusetts Institute of Technology (81 feet in length, 7–15 feet in diameter). Note the window in the center where the models are viewed

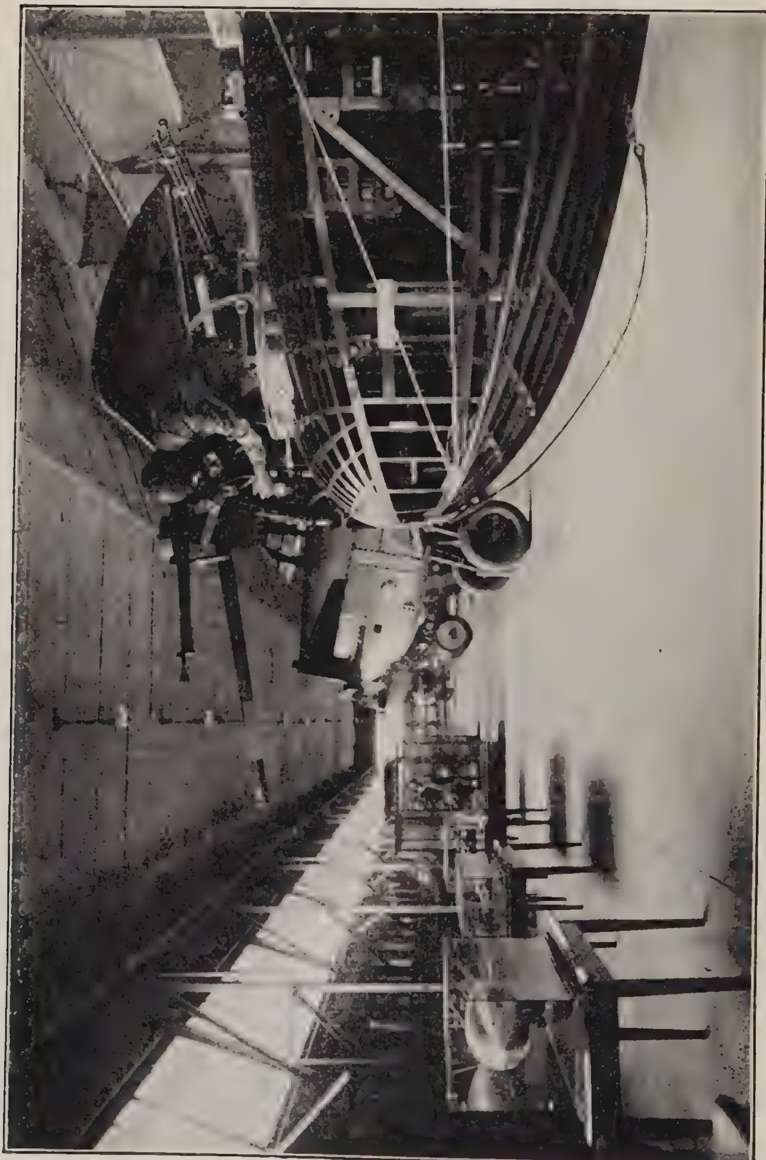
developed a very helpful device for testing models. They realized that to simulate flight it was necessary either to have an aircraft going through the air or the air going past an aircraft. The latter method permitted the best observation of the aircraft's behavior, so a long tunnel was built in which the model was carefully suspended. When air was blown through the tunnel and the model was observed, a conclusion was reached as to the probable behavior of a similar craft when in actual flight.

Wind tunnels have been improved constantly and now are recognized as an efficient method of making aerodynamic tests, combining accuracy and economy. The illustration shows a



(Courtesy: U. S. N. M.)

Figure 190. A Model Airplane Exhibit Conducted at the National Museum by the Capitol M. A. C.



(Courtesy: U. S. N. M.)

Figure 191. The National Museum, Aircraft Building, Showing Several Cases of Models in the Left Foreground

wind tunnel, which has a propeller at one end for creating the wind, and a honeycomb for changing the wind from a whirling stream to one flowing in parallel lines. So valuable is this method that manufacturers maintain a shop for making models of their designs for wind tunnel tests.

Another use for model airplanes is found in patent litigation. The Chinese say, "A picture is worth ten thousand words." A model is a great improvement over a picture, so inventors realizing this prefer to illustrate their ideas with working models that most efficiently demonstrate their inventions.

Model airplanes, especially scale models, form attractive displays and are in demand for exhibition at banquets honoring noted fliers. At Richmond, Virginia, when a dinner was given to Colonel Charles Lindbergh, the hall was very beautifully hung with models, including one of Lindy's own plane in which a concealed electric motor realistically revolved the propeller. Manufacturers recognize that a well-made model is an excellent advertisement for their product. Motion picture houses and theaters frequently use models in their lobbies to arouse interest in any aerial feature that is billed. The motion picture industry frequently uses accurate operative models to substitute for the real machine in executing some particularly difficult or expensive act. A well arranged display of model aircraft never fails to attract passers-by to a store window, and such exhibits are valuable toward keeping virile the public's interest in flight.

Another great field for the model airplane lies in education. Nowadays many persons are eager to learn more about flying. Accurately made model airplanes illustrate in an effective manner the principles of flight and methods of construction for the benefit of aeronautic students and other interested persons. Flying schools usually have several models as part of their

equipment, models being much cheaper than full-sized machines, and for some purposes just as valuable as a prototype. The National Museum at Washington, which maintains the most

Figure 192. Assistant Secretary E. P. Warner admiring the winning model of the 1927 Tournament made by Jack Lefker

complete exhibit of famous aircraft in the world, uses many models to illustrate the story of flight.

Many men who are today prominent in aeronautics got their start making and flying model airplanes. The Wright brothers have already been cited. Another prominent example is the Hon. Edward P. Warner, present Assistant Secretary of the

Navy in Charge of Aeronautics, who was active in founding model flying as a sport in Boston, and today he maintains a keen interest in the sport. Grover C. Loening, famed designer of aircraft, first graduate of an aeronautical engineering collegiate

Figure 193. Clarence Chamberlin admiring a model of the plane he made famous. (See Chapter XVII.) Model by Carl Fastje

course, inventor and builder of the Loening Amphibian planes which made the Pan-American Good-Will flight in 1927, was a model flyer back in 1910. William B. Stout, maker of the Ford-Stout all-metal planes; Clarence Chamberlin, noted trans-atlantic and duration pilot; Rudolph Schroeder, former holder of the world altitude record; Emil Laird, designer and builder of the Laird "Swallow" and other airplanes; and many others willingly acknowledge their indebtedness to model aeronautics for the beginning of subsequent aeronautic success.

A wise and far-seeing Providence from time to time has blessed the world with inventors, who through their superior knowledge have advanced civilization. These have been followed by able men who improved upon the various devices and broadened their use. So it is with the airplane; the men who have followed da Vinci, Cayley, Stringfellow, Langley,

the Wrights, and others, have each added their bit to the ultimate perfection that is coming. Men now living are doing their share in this advancement, but it is the model fliers of today who tomorrow will carry on the work, giving to the world a wonderful system of air transportation that ultimately will reach every community on the face of the earth.

TERMS USED

The following are technical terms that the reader may not find in the usual dictionary.

Aileron. Part of the trailing edge of a wing which is movable and used to roll or balance the airplane.

Airfoil. Any surface designed to be moved through the air to produce a useful action.

Angle of attack. The acute angle between the chord of an airfoil and its direction of motion relative to the air.

Angle of incidence. The angle of wing setting, relative to the line of motion.

Aspect ratio. The ratio of wing span to wing chord.

Cabane. A post or framework for attaching braces.

Camber. The rise in curve of an airfoil section from its lowest part.

Catedral. A downward angle of wing setting, opposite of dihedral.

Chord. Distance from entering edge to trailing edge of a wing. (For technical definition see N.A.C.A. Report No. 240.)

Decalage. The angle between the wings on a biplane.

Dihedral. An upward angle of wing setting. Used to impart automatic stability.

Elevators. Surfaces for changing the angle of climb on a model.

Empennage. Tail surfaces.

Entering edge. The foremost edge of a wing or propeller blade.

Gap. The distance between the main wings of a biplane.

Joy stick. The control stick of an airplane; used for altitude and balance.

Pitch. The distance that a propeller advances along its line of flight for one revolution.

Pitch, actual. Geometrical pitch minus slip.

Pitch, geometrical. The distance a propeller would advance, rotating in a solid.

Pusher. A model whose propeller or propellers are behind the main wing.

Slip. Loss due to "give" of the air.

Span. The maximum distance, measured parallel to the lateral axis from tip to tip of a wing, including ailerons.

Stabilizer. A fixed surface whose function is to lessen pitching longitudinally.

Sweepback. The angle formed when the longitudinal center line of a wing is bent backward.

Tractor. A pulling propeller. A model whose propeller is in front of its main wing.

Trailing edge. The rearmost edge of an airfoil or propeller blade.

Abbreviations Used in Model Aeronautics

H.L. Hand-launched.

R. O. F. Rise off floor.

R. O. G. Rise off ground.

R. O. W. Rise off water.

R. P. M. Revolutions per minute.

S. S. V. T. Single stick, Vee-tail. A "Fleming-Williams" type model. (See Chapter VII.)

INDEX

S

T

U

V

W